Proposed Offshore Wind Procurement Strategy for Delaware

Prepared by the DNREC Division of Climate, Coastal and Energy, Synapse Energy Economics, and Zooid Energy

December 29, 2023

DELAWARE DEPARTMENT OF
NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

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1.0 Executive Summary

This report represents the most recent step in Delaware's ongoing effort to develop an offshore wind (OSW) procurement strategy that fits the state's policy needs and objectives. DNREC, through the Division of Climate Coastal and Energy, has been working to monitor and analyze the prospects for offshore wind development. This report proposes an offshore wind procurement program for Delaware that builds on the broad recommendations of the Offshore Wind Working Group, incorporates the market intelligence and technical analysis found in the Special Initiative on Offshore Wind (SIOW) report, is based on the centrality of renewable energy in the Climate Action Plan (codified in the Climate Solutions Act), and covers the topics enumerated in the Delaware Energy Act (29 *Del.C*. § 8051 and § 8056). This report was being prepared as the deliberations of the Governor's Energy Advisory Council concluded in December of 2023 and is independent of the Council's recommendations.

This report addresses the challenges of a small state engaging effectively in an industry in which scale is paramount. The strategic value of offshore wind for Delaware is underscored by the fact that there are not many other options available for delivering sufficient renewable energy at the scale that will be needed to meet the state's renewable energy goals, which in turn will be crucial to meeting Delaware's climate goals.

This report comes at a time of considerable uncertainty in the offshore wind industry, and in energy markets more generally. It reviews these changing conditions, identifies key factors to consider in developing an offshore wind strategy, identifies key developments coming up in 2024 that will affect planning, and offers recommendations on how to best structure an offshore wind procurement program to meet Delaware's needs.

DNREC tasked Synapse Energy Economics (Synapse) with performing benefit cost and macroeconomic impact analyses of a hypothetical 800 megawatt (MW) project.

Based on this analysis, and building on previous work, this report offers the following recommendations:

1. Delaware should proceed with legislation authorizing the procurement of offshore wind to serve Delaware, either as a standalone project or in partnership with other states.
2. DNREC should prepare model legislation to establish a path forward on offshore wind procurement that best serves the needs of Delaware.
3. DNREC should be the lead agency in developing an offshore wind procurement program.
4. The procurement program should encompass as much flexibility (in terms of timing, scale, location, and agreement structure) as possible to best adapt to changing industry conditions.
5. The procurement program should be developed in consultation with all Delaware utilities, mindful of their differing governance structures and business practices.
6. The procurement program should maximize long-term value and minimize ratepayer impacts.
7. The procurement program should provide for economic development and workforce development without adding specifications that would drive up the cost.
8. The procurement program should include possible partnerships with neighboring states on subjects including procurement, transmission, and supply chain development to take advantage of economies of scale beyond those of Delaware's buying capacity.
9. The procurement program should be structured to promote the coordinated, cost-effective buildout of the transmission system on a regional scale.
10. The procurement program should consider potential environmental and natural resource impacts and include ways to avoid, minimize, or mitigate these impacts in planning for offshore wind procurement.
11. DNREC should update its analysis and adapt this strategy on an ongoing basis as more information becomes available.

Given the current uncertainties in the offshore wind market (and energy markets in general), an effective procurement strategy must include flexibility for Delaware to respond to future changes in market conditions. Concurrent with this report, DNREC is preparing model legislation to establish a path forward on offshore wind procurement that incorporates the need for flexibility and ongoing analysis.

2.0 Background

The proposed offshore wind procurement strategy in this report builds on the statutory foundation of the Renewable Energy Portfolio Standards Act (REPSA) and the Climate Solutions Act and furthers the recommendations of the Offshore Wind Working Group, the Special Initiative for Offshore Wind, as well as DNREC's ongoing monitoring and analysis of offshore wind industry conditions.

Governor John Carney established the Offshore Wind Working Group in August 2017 to study opportunities for Delaware to participate in developing offshore wind. The Offshore Wind Working group included a diverse group from government, industry, and the public. The Working Group held a series of formal meetings and public comment workshops in 2017 and 2018 to develop its Report to Governor Carney (June 29, 2018).[1] In its report, the Offshore Wind Working Group advised against procuring offshore wind at that time and identified several options for additional study, including large scale purchases, incremental commitments to future projects, waiting until additional developers propose projects in the Mid-Atlantic Region and evaluating other renewable energy sources. The strategy presented in this report follows upon the 2018 recommendations by examining each of those options.

Governor Carney released *Delaware's Climate Action Plan*[2] in 2021, which outlines the actions needed to reduce Delaware's GHG emissions 26 percent to 28 percent from 2005 levels by 2025. The Climate Action Plan finds that the expansion of clean and renewable energy has the greatest potential to reduce emissions in the long term. The Climate Solutions Act, which was signed into law by Governor Carney in August 2023, sets net greenhouse gas reduction targets of 50 percent from a 2005 baseline by January 1, 2030, and net zero GHG emissions by January 1, 2050, and declares that "the Climate Action Plan shall serve as the framework to guide all State agencies" in achieving these targets.

The Special Initiative on Offshore Wind (SIOW) at the University of Delaware prepared a report, *Offshore Wind Procurement Options for Delaware*[3], in 2022 at the request of DNREC Secretary Shawn Garvin and key legislative leaders. The purpose of the request was to conduct analysis of market conditions and options for developing offshore wind to serve Delaware. The SIOW is an independent project at the University of Delaware's College of Earth, Ocean and Environment that supports the advancement of offshore wind. While the 2022 SIOW report offered a variety of useful insights to inform Delaware's offshore wind discussions, it did not address all the options put forward by the Offshore Wind Working Group. In particular, the SIOW report recommended an 800 MW project as the optimal size and a power purchase agreement (PPA) as the preferred procurement structure for Delaware. The procurement strategy proposed here would be more flexible on both points. First, it may be that one or more incremental additions to projects procured by other states would better fit Delaware's limited purchasing power. Second, this strategy would also be flexible on the question of procurement structure and would involve further analysis and consultation with key stakeholders before opting for a PPA (which is used in New York, Connecticut, Rhode Island, and Massachusetts) or an OREC (Offshore Wind Renewable Energy Credit) structure (which is used in Maryland and New Jersey).

Building on this previous work, DNREC is tasked in the Delaware Energy Act (29 *Del.C.* § 8056) with studying and providing recommendations to the Governor and the General Assembly on a process for procuring offshore wind power by December 31, 2023. This report covers the topics specified in § 8056 along with several other key considerations not specified in the section. This section also authorizes DNREC to work with PJM Interconnection and neighboring states on offshore wind transmission planning. This report builds on the aforementioned previous work and, where necessary or appropriate, specifies further analysis going forward. An effective procurement strategy must include the flexibility to respond to changes in market conditions.

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[1] Offshore Wind Working Group Report to the Governor (delaware.gov)
[2] Delaware's Climate Action Plan
[3] SIOW, Offshore Wind Procurement Options for Delaware

3.0 Analysis

The Delaware Energy Act (29 *Del.C.* § 8056), as updated by Senate Bill 170 in 2023, specifies topics to be included in offshore wind procurement planning:

(c) Offshore Wind Procurement Planning.

(1) The Department shall study the procurement processes, including those used in other Atlantic states for electricity from offshore wind projects, evaluate the options for conducting and evaluating a request for proposal process to procure offshore wind power, and prepare recommendations for potential offshore wind procurement. Any procurement process should consider at least the following:

(i) The long-term cost impact, if any, on ratepayers in Delaware.

(ii) Potential economic costs and benefits for the State and for Delawareans.

(iii) The consistency of such a procurement with the Delaware Climate Action Plan, the Delaware Energy Plan, and the ability of the State to meet its Renewable Energy Portfolio Standards.

(iv) The avoided costs of greenhouse gas emissions and other air pollutants on the State from power generation sources.

(v) Potential health benefits for the State and for Delawareans.

(vi) The availability and scale of suitable offshore wind locations.

(vii) The state of the offshore wind industry and associated supply chains.

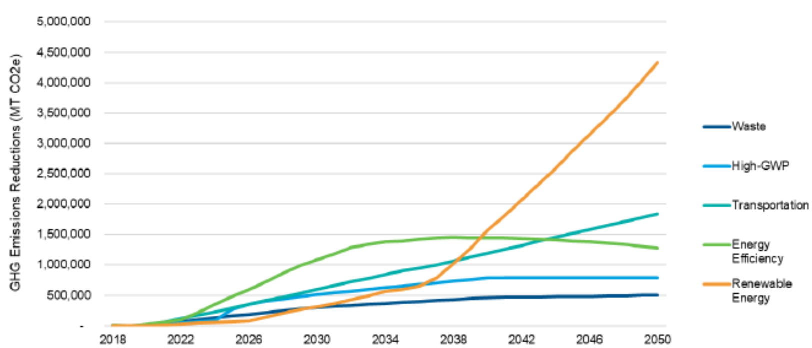
(viii) The impacts on the electricity transmission system.

In considering these and other criteria, this report identifies the current analysis, ongoing work, and methods for developing a proposed procurement program. DNREC engaged Synapse Energy Economics to construct benefit cost and macroeconomic analyses of the costs and benefits of procuring offshore wind. These models, which encompass most of the other factors considered in this report, are summarized later in this section.

3.1 Consistency with the Delaware Climate Action Plan, the Delaware Energy Plan, and the Ability of the State to Meet its Renewable Energy Portfolio Standards

The Climate Solutions Act, which was signed into law by Governor Carney in August 2023, sets net greenhouse gas reduction targets of 50 percent from a 2005 baseline by January 1, 2030, and net zero GHG emissions by January 1, 2050, and declares that "the Climate Action Plan shall serve as the framework to guide all State agencies" in achieving these targets. The top three GHG reduction actions identified in the Climate Action Plan (CAP) are energy efficiency, transportation, and renewable energy as shown below. Renewable energy is projected to have the greatest impact over the long term and is key to increasing the GHG reduction value of electric vehicles over time.

Figure 1: Gross GHG emissions reductions by mitigation category (metric tons)



Delaware Climate Action Plan Supporting Technical GHG Mitigation Analysis Report, p. 24[4]

[4] ICF: Delaware Climate Action Plan Supporting Technical Greenhouse Gas Mitigation Analysis Report. August 31, 2020, p. 24, https://documents.dnrec.delaware.gov/energy/Documents/Climate/Plan/DNREC Technical Report.pdf

3.2 Avoided Costs of Greenhouse Gas Emissions and Other Air Pollutants and Potential Health Benefits for Delawareans

The Climate Action Plan assumed that 50 percent of the RPS requirement would be satisfied by offshore wind, and the remaining portion would be satisfied by other types of renewables. The CAP projected that annual gross emission reductions attributed to renewable energy compared to the 2025 business as usual (BAU) case would be 421,700 MT CO_2e in 2035 and 4,306,500 MT CO_2e in 2050, with half of these reductions attributed to offshore wind. DNREC is currently updating this analysis.

Synapse has modeled the projected annual avoided GHG impact of an 800 MW offshore wind project connecting into Delaware in 2035 and its lifetime avoided GHG impact from 2031 to 2050 as shown in the table below. (This analysis considers a project of this scale, not as a recommendation, but for benchmarking purposes to inform decision-makers.) The lifetime total captures a decline in avoided GHG impacts per MWh of renewable generation over time as renewables represent a greater proportion of energy generation in the region.

Table 1: Avoided CO2 (short tons)

Scenarios	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Annual Total	Lifetime Total
Mid gas price	97,767	31,658	61,913	24,507	215,844	2,723,618
High gas price	146,406	46,080	86,153	29,005	307,645	3,756,073

Synapse also modeled the projected annual (in 2035) and lifetime avoided NOx and PM2.5 impacts as shown in the table below. SO2 is not avoided since coal is the only type of resource that emits SO2 and coal is not present in PJM-EMAAC. The avoided PM2.5 impacts do not change for the different scenarios since the sources for PM2.5 emissions rates provide average emissions rate impacts that are not specific to the different gas price scenarios.

Table 2: Avoided other air pollutants (short tons)

Scenarios	NOx		PM2.5	
	Annual Total	Lifetime Total	Annual Total	Lifetime Total
Mid gas price	17	211	63	791
High gas price	22	275	63	791

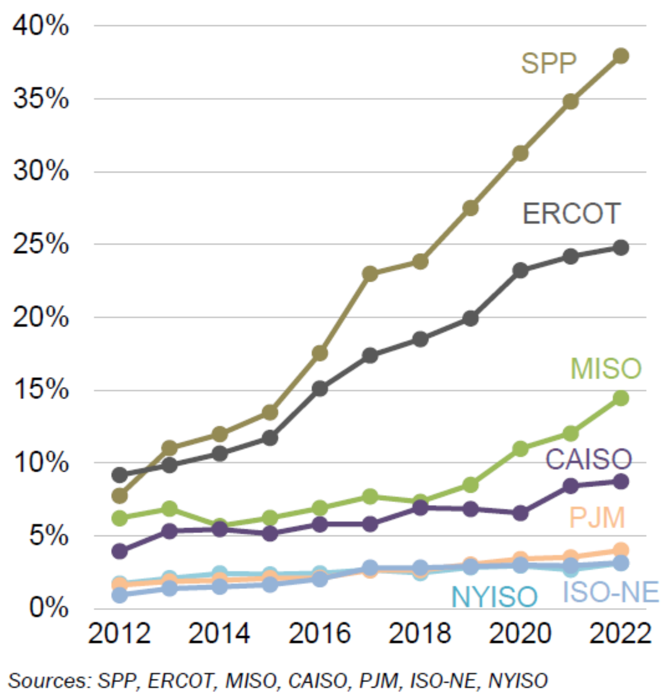
3.3 Availability of RECs to Meet Delaware's RPS Requirements

Delaware's renewable energy goals are set by the Renewable Energy Portfolio Standards Act (REPSA), which requires electric utilities to procure an increasing percentage of their power from renewable energy, culminating in 40 percent renewable energy (including a 10 percent solar carve-out) by 2035. (The percentage does not apply to large industrial users, which reduces the amount of load subject to the RPS by 12 percent for DPL for instance.) REPSA defines renewable energy resources as being located in or delivered into the PJM region. Location matters when it comes to contributing to meeting the goals of the Climate Action Plan, which requires adding clean generation to the grid serving Delaware. Most of the wind power used for Delaware RPS compliance is located out of state (western Pennsylvania in the case of DPL), while most of the solar power used to meet the solar carve-out is located within Delaware. A MWh of power from an offshore wind project connected into Delaware should have greater impact on local grid emissions than a MWh from a wind project in western Pennsylvania.

Until recently, land-based wind power was relatively cheap and plentiful, and Delaware's utilities met their growing RPS requirements by buying RECs (and energy in some cases) from projects in western Pennsylvania. Earlier this year, DPL reported that it could not procure sufficient wind RECs below the alternative compliance payment (ACP) level of $25/MWh for the first time since the RPS was established. DPL instead submitted a payment of $12,974,250 to the Green Energy Fund in lieu of 518,970 RECs it could not buy at or below $25/MWh. The supply of wind RECs at or below the ACP price may not be sufficient for 2024 as well.

Only five years ago, DPL was able to procure a ten-year RECs only contract at $8.10/MWh, which runs through 2028. This was a departure from DPL's earlier wind contracts, which included energy and RECs. While DPL's inability to buy RECs for less than the ACP of $25/MWh this year seemed like an abrupt turn of events, there have been recent signs that land-based wind supplies were not keeping pace with demand. The *Land-Based Wind Market Report: 2023 Edition*[5], published annually by the U.S. Department of Energy, shows that the PJM region lags in the growth of wind resources.

Figure 2: Wind market share (%)



Source: NREL, *Land-Based Wind Market Report: 2023 Edition*, p. 10

Delmarva Power's four contracts for land-based wind generate roughly 420,000 RECs annually, just six percent of DPL's non-exempt load. Larger wind projects are coming online that would deliver more renewable energy into western PJM, but those projects may not come fast enough to meet the growing demand within PJM. By contrast, an 800 MW OSW project with a capacity factor of 43 percent would generate 2,996,450 MWh annually, enough to cover the REC requirements (30 percent of non-exempt load) of all of Delaware's utilities in 2035.

For now, there is not enough land-based wind within PJM to meet Delaware's RPS needs. What capacity is available is located hundreds of miles west of Delaware and will have little if any impact in decarbonizing the grid in Delaware. Developing the transmission capacity to deliver larger scale land-based wind from the Great Plains to the western PJM region is also proving challenging. The Grain Belt

[5] USDOE: Land-Based Wind Market Report: 2023 Edition, p. xi, https://www.energy.gov/sites/default/files/2023-08/land-based-wind-market-report-2023-edition.pdf

Express, which would deliver 3.5 GW (and eventually 7.0 GW) of land-based wind from Kansas to Illinois, has won approval from the Missouri Public Service Commission, but is now being challenged at FERC.[6] Given the lag between the development of land-based wind and the demand for renewable energy in PJM, offshore wind may be necessary to meet Delaware's RPS requirements.

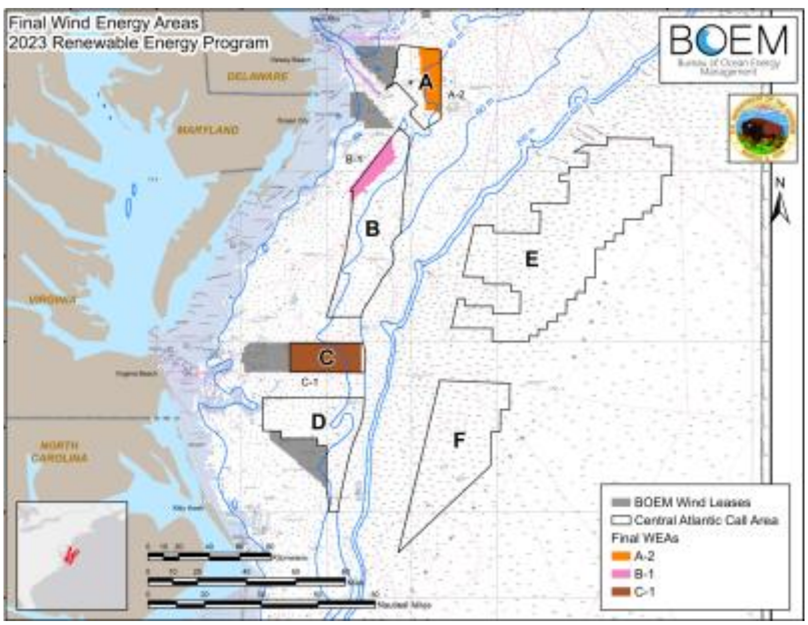
3.4 Availability and Scale of Suitable Offshore Wind Locations

REPSA specifies that renewable energy resources be "located within or imported into the PJM region," (29 *Del.C.* § 352 (7)) which means that offshore wind projects connecting into NJ, DE, MD, VA, or even northeast NC could be eligible to meet DE RPS requirements.

Offshore wind projects that could serve Delaware could be located in already established Wind Energy Areas (WEAs) or in new WEAs designated by the Bureau of Ocean Energy Management (BOEM). Existing WEAs that could accommodate projects to serve Delaware include the DE and MD WEAs controlled by Ørsted (estimated capacity of 1,080 MW) and US Wind (estimated capacity of 600 MW). There is additional capacity available to connect into NJ that could also serve DE.

BOEM has announced three final WEAs off the coasts of Delaware, Maryland, and Virginia, which were developed following engagement and feedback from states, Tribes, local residents, ocean users, other federal agencies, and other members of the public.

Figure 3: BOEM Wind Energy Areas



Source: https://www.boem.gov/renewable-energy/state-activities/central-atlantic.

BOEM announced a new proposed lease sale in the mid-Atlantic on December 11, 2023.[7]

> The proposed lease sale includes one area offshore the states of Delaware and Maryland, and one area offshore the Commonwealth of Virginia. Lease Area A-2 consists of 101,443 acres and is approximately 26.4 nautical miles (nm) from Delaware Bay. Lease Area C-1 consists of 176,505 acres and is approximately 35 nm from the mouth of the Chesapeake Bay. BOEM is

[6] "Invenergy's 5-GW Grain Belt transmission project faces continued opposition at FERC," *Utility Dive*, Oct. 24, 2023, https://www.utilitydive.com/news/invenergys-5-gw-grain-belt-transmission-project-faces-continued-opposition/697454/
[7] https://www.doi.gov/pressreleases/interior-department-proposes-offshore-wind-sale-central-atlantic

> seeking public comments on which, if any, of the two lease areas should be offered in a lease sale next year.

The Oceantic Network, an offshore wind business advocacy group, commented that the new WEAs identified by BOEM will not be sufficient to meet all of the needs of mid-Atlantic states.

> However, [the Oceantic Network] noted that it is insufficient to meet Maryland and North Carolina's offshore wind goals individually and collectively and would leave little room for states like Delaware to enter the offshore wind industry, even though an agreement between the Biden-Harris administration and Governor Moore seeks to identify new areas for a 2025 auction geared towards meeting Maryland's goals.[8]

DNREC has been engaged in BOEM's WEA planning process and has expressed Delaware's interests in expanding the availability of WEAs that can be connected into PJM consistent with the protection of sensitive natural resources.

3.5 State of The Offshore Wind Industry and Associated Supply Chains

The offshore wind industry has been a mixed picture in recent months as shown below.

Table 3: Summary of OSW projects on the eastern seaboard

Status	Number of Projects	Lease Areas	Contracting States	Capacity in MW	Announced Commercial Operations Date
Operational	2	RI, VA	RI, VA	42	Operational
Under Construction/Final Investment Decision	3	MA, MA/RI, RI		1,636	2024-2026
Under Permitting	9	ME, NY NJ, MD, VA	ME, NY NJ, MD, VA	8,754	2024-2028
Possible Rebid/Work Stopped	4	MA, DE	NY, MD	3,396	2026-2029
Withdrawn	9	MA, RI, NJ	CT, MA, NY	7,968	2025-2029
Planning/Site Control	11	ME, MA, RI/MA, NY/NJ, NJ, DE	NY	14,451	TBD
Total All Projects				**36,247**	

Two projects totaling 42 MW are operational. Nine projects (including US Wind) totaling 8,754 MW are under permitting. (This total includes 600 MW of capacity US Wind could build out in the MD WEA.) Four projects have either stopped work or are seeking a possible rebid. This includes Ørsted, which has stopped work on Skipjack 1 and 2 in Maryland. Nine projects totaling 7,968 MW have been withdrawn. Three projects totaling 1,636 MW are under construction or awaiting final investment decision. Developers have site control of lease areas from ME to DE to build a further 14,451 MW. This includes a portion of the DE WEA designated for Garden State Offshore Energy and controlled by Ørsted.

The offshore wind industry is currently facing challenges on supply chain disruptions and increased cost of capital. This can be exemplified through the experiences of Ørsted over the last six months through its press announcements. On August 29, 2023, Ørsted announced that it anticipates recognizing an impairment charge of 16 billion Danish Kroners or approximately $2.2 billion due to adverse conditions surrounding supply chain, investment tax credit, and interest rate exposure of its US offshore wind portfolio.[9] Ørsted's press release specifically referenced adverse conditions impacting the following projects: Ocean Wind 1 in New Jersey, Sunrise Wind in New York, and Revolution Wind in Rhode

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[8] https://www.rivieramm.com/news-content-hub/boem-proposes-offshore-wind-sale-in-the-central-atlantic-78891

[9] Ørsted. "Ørsted announces anticipated impairments on its US portfolio, continues to progress projects" August 29, 2023. Available at https://orsted.com/en/company-announcement-list/2023/08/oersted-announces-anticipated-impairments-on-its-u-71411

Island and Connecticut. Ørsted did not specifically mention Skipjack Wind 1 or Skipjack Wind 2 projects in the August press release.

On October 12, 2023, the New York Public Service Commission issued an order in Cases 15-E-0302 and 18-E-0071 that preserves New York's competitive bidding process for renewable projects.[10] Sunrise Wind LLC and other renewable project developers had petitioned the New York PSC to adjust approved REC and OREC strike prices.[11] The New York PSC ultimately denied the petitioners' request to adjust REC and OREC prices since an adjustment "would compromise the price integrity and equity derived from New York State's longstanding competitive procurement process."[12] As noted above, Ørsted identified Sunrise Wind as a contributing project to Ørsted's $2.2 billion impairment charge.

On October 31, 2023 Ørsted issued its 3rd Quarter earnings.[13] In its press release, Ørsted increased its August 29th impairment of $2.2 billion to almost $4.2 billion. The company provided a detailed breakdown of the $4.2 billion impairment. Ørsted attributed approximately $2.5 billion of the $4.2 billion impairment to supply chain disruptions to its US portfolio of projects. Specifically, Ørsted realized that it would not have an available installation vessel available for the Ocean Wind 1 project in time for its scheduled completion date.[14] Ørsted attributed approximately $900 million of its $4.2 billion impairment to changes in interest rates that have increased project costs for the company.[15] Ørsted noted that for its capital structure, a change in 50 basis points in its weighted average cost of capital would result in a change of approximately $294 million in interest costs.[16]

3.6 Impacts on The Electricity Transmission System

One of the biggest uncertainties in terms of cost and execution is transmission, which includes connecting projects to shore and the necessary upgrades to the transmission grid to accommodate the power being injected into the system. Two Maryland wind developers, Ørsted and US Wind, have already identified their preferred interconnection points in Delaware, which means that Delaware is involved in offshore wind transmission planning even before proceeding with a procurement plan. Delaware is a small state with few points of possible interconnection. Shared transmission corridors may be key in addressing space concerns, as well as impacts to Delaware's natural resources and to those who depend on them for functional, economic, recreational, and aesthetic purposes.

Offshore solicitations in other states have been addressing the need for shared transmission for these reasons. In 2020, New Jersey utilized the State Agreement Approach (SAA) for planning transmission infrastructure related to offshore wind. This allowed New Jersey "to explore options for an optimal long-term solution for offshore wind transmission that otherwise may not have been available at this stage of development."[17] With the increase in New Jersey offshore wind procurement goals, the New Jersey Board of Public Utilities requested in the spring of 2023 that PJM incorporate these goals into the SAA and address the associated transmission infrastructure needs. Further, New Jersey's third solicitation requires that developers include "mesh-ready" designs in their proposals.

[10] New York Public Service Commission. *PSC Issues Decision to Preserve Competitive Renewable Energy Market and Protect Consumer.* October 12, 2023. Available at https://dps.ny.gov/system/files/documents/2023/10/pr23105.pdf
[11] French, M. "Renewable developers, pinched by inflation, to ask for increased subsidies" Politico. June 5, 2023. Available at https://www.politico.com/news/2023/06/05/renewable-developers-pinched-by-inflation-ask-for-increased-subsidies-00099896
[12] New York Public Service Commission. *Order* Cases 15-E-0302 and 18-E-0071. October 12, 2023. Page 54. Available at https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={E0C7248B-0000-C91F-9B56-50CC9643132E}
[13] Ørsted. "Interim report for the first nine months of 2023- Cease the development of Ocean Wind 1 and Ocean Wind 2, took final investment decision on Revolution Wind, and impairment losses of DKK 28.4 billion" October 31, 2023. https://orsted.com/en/company-announcement-list/2023/10/interim-report-for-the-first-nine-months-of-2023---73721
[14] Ørsted. "Investor presentation Q3 2023" October 31, 2023. Slide 4. Available at https://orsted.com/en/company-announcement-list/2023/10/interim-report-for-the-first-nine-months-of-2023---73721
[15] Ibid.
[16] Ibid.
[17] https://www.njcleanenergy.com/renewable-energy/programs/nj-offshore-wind/transmission

Maryland may also look to utilize the PJM SAA process for transmission considerations with the recent approval of the Promoting Offshore Wind Energy Resources Act (POWER Act)[18] by the Maryland General Assembly. The POWER Act also directs that the Maryland Public Service Commission "shall evaluate the potential for cooperating with other states in the PJM region to maximize consumer benefits that will best achieve the state's renewable energy and offshore wind energy goals." The POWER Act also directs that "on or before July 1, 2025, the Commission shall issue, or request that PJM Interconnection issue, one or more competitive solicitations for proposals for open access offshore wind transmission facilities and necessary complementary onshore transmission upgrades and expansions."

The Delaware Energy Act (29 *Del.C*. § 8056) tasks DNREC to "cooperate with PJM Interconnection in an analysis of the impacts on transmission of offshore wind procurement goals" and "consult with the PSC, the DPA, and all electric utilities in Delaware" before initiating this cooperation. DNREC's consultations with the PSC, DPA and electric utilities took place in October. At PJM's request, Secretary Garvin and PSC Chairman Dallas Winslow sent PJM a letter to formally start this process in November, asking PJM to model 1,000 MW of offshore wind connecting into Delaware. The letter "emphasized that this [request] does not represent a policy commitment at this time but is intended to be part of our ongoing analysis of Delaware's policy options." PJM responded by letter on December 6 and DNREC is working with PJM on executing the study.

The Department of Energy (DOE) Grid Deployment Office has been leading an effort to evaluate multiple pathways to offshore wind goals through coordinated transmission solutions along the Atlantic Coast in the near-term (2030) and long-term (2050).[19] The study is being conducted by the National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL). Interstate coordination and cooperation play a central role in DOE's long-term action plan.

> **Before 2025:** Establish collaborative bodies that span the Atlantic Coast region; clarify some of the building blocks of transmission planning, including updating reliability standards and identifying where offshore transmission may interconnect with the onshore grid; and address costs through voluntary cost assignments.
> **From 2025 to 2030:** Simultaneously convene and coordinate with states to plan for an offshore transmission network; with industry to standardize requirements for HVDC technology; and with federal agencies, tribal nations, state agencies, and stakeholders to identify and prioritize transmission paths on the outer continental shelf.
> **From 2030 to 2040:** Establish a national HVDC testing and certification center to ensure compatibility when interconnecting multiple HVDC substations to form an offshore grid network and codify updates to transmission planning through regulated interregional joint planning, transfer capacity minimums, and market monitoring.[20]

Delaware has also been participating in the Northeast States Transmission Collaborative, an ongoing planning effort sponsored by the DOE Grid Deployment Office and led by the Center for Global Energy Policy at Columbia University. The project benefits are described as "constructing an offshore wind transmission 'superhighway' that would allow offshore wind farms to connect to an ocean-based grid directly, without each farm site having to construct its own transmission facilities and go through the slow process of permitting and siting those facilities across a conflicting web of federal, state, and local rules."[21]

Governor Carney announced on December 19, 2023 the start of formal negotiations between Delaware and US Wind on connecting its two planned offshore wind projects to the grid in Delaware.[22] While these projects are being built to meet Maryland's offshore wind objectives, Delaware still has the complex task of managing the many facets of connecting a large offshore wind project to the grid in Delaware.

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[18] https://mgaleg.maryland.gov/2023RS/bills/sb/sb0781e.pdf
[19] https://www.nrel.gov/wind/atlantic-offshore-wind-transmission-study.html
[20] https://www.energy.gov/gdo/atlantic-offshore-wind-transmission-action-plan
[21] https://www.energypolicy.columbia.edu/an-offshore-wind-super-grid-for-the-east-coast/
[22] "Delaware to Negotiate with US Wind Over Benefits for State," https://news.delaware.gov/2023/12/19/delaware-to-negotiate-with-us-wind-over-benefits-for-state/

The common thread among these planning efforts is that a coordinated transmission planning approach will be more efficient and cost-effective than the radial approach of connecting one project at a time, particularly for Delaware, which has a limited number of feasible connection points and a grid that is not capable of accommodating multiple GWs of offshore wind without large scale upgrades. Because piecemeal radial interconnections are expensive and time consuming, Delaware needs to be involved in regional transmission planning as an essential part of its offshore wind strategy.

3.7 Potential Economic Costs and Benefits for Delaware

DNREC tasked Synapse to develop a societal benefit-cost analysis (BCA) and macroeconomic impact analysis to inform Delaware's investment in offshore wind resources and potential contribution toward the transmission costs needed to bring that wind ashore.

The Synapse analyses should be considered provisional, pending ongoing refinement as other data and analysis becomes available, such as ongoing work by PJM on possible transmission costs, work by the National Renewable Energy Laboratory (NREL) on OSW component costs, work by ICF[23] on behalf of DNREC to quantify health impacts associated with various pollutants, and work with neighboring states on supply chain opportunities.

Factors included in the analyses include the cost of offshore wind resources in 2030 and the estimated benefits from 2033 to 2050, such as the avoided energy, capacity, REC, carbon, and health costs. Offshore wind cost declines are expected over time with gains in scale and experience but can be offset by market forces like inflation and interest rate fluctuations. Gas prices could be higher if new Liquified Natural Gas (LNG) ports ship more domestic gas to international customers. Capacity market structures could change, including accreditation for renewable resources such as wind energy. Changes to Renewable Energy Credit (REC) market structures could result in changes to supply and/or pricing. Estimates of the social cost of carbon and the cost of health impacts associated with various pollutants are evolving over time.

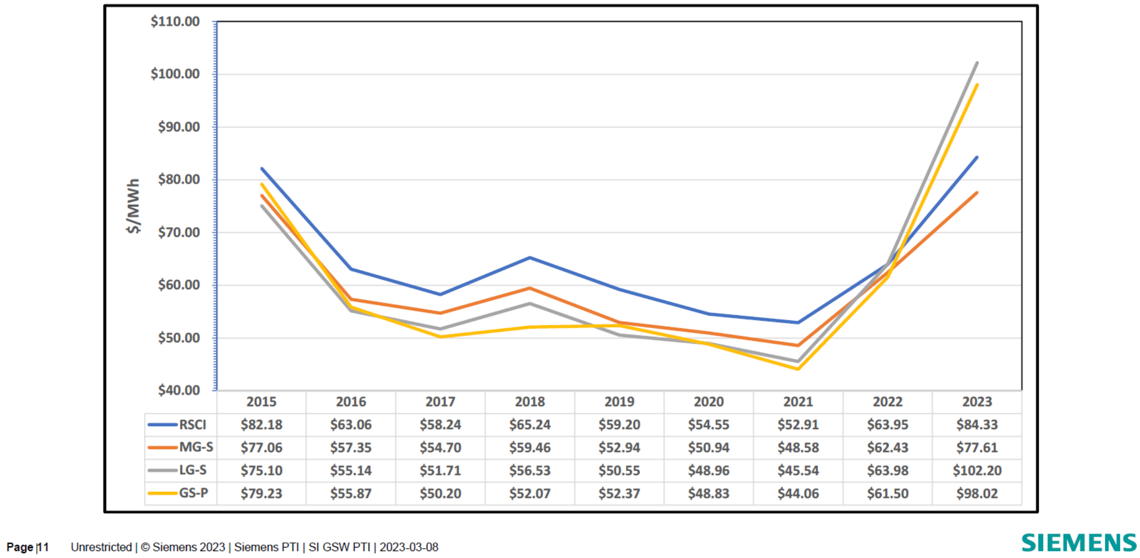
The once-stable domestic market is being increasingly exposed to global market conditions, as demonstrated by the spike in prices brought on by the Russian invasion of Ukraine, when US natural gas supplies were tapped to fill Europe's energy needs. This exposure to global market pressures continues to grow. According to the U.S. Energy Information Administration (EIA), the first US LNG export terminals came online in 2016.[24] Since then, export capacity has grown to 14.44 billion cubic feet per day (Bcf/d) according to the Federal Energy Regulatory Commission (FERC) and is projected to grow to 51.27 Bcf/d.[25]

An analysis of winning bids for DPL's standard offer service (SOS) customers since 2015 shows this volatility, with prices for RSCI (residential, small commercial and industrial) customers ranging from $54.55/MWh to $84.33/MWh. Because natural gas markets are less insulated from global market forces, the analysis includes a high gas price scenario.

Synapse calculates that an 800 MW offshore wind project that becomes fully operational in 2031 would need to sell power between $86/MWh to $91/MWh, depending on the wind learning rate, which is the rate at which technological efficiencies and economies of scale reduce the cost of building and operating an offshore wind project. When discounted to 2022 dollars, these projected prices are $64/MWh to $68/MWh, which would not be inconsistent with the range of recent power prices in Figure 4 below.

[23] https://www.icf.com/company/about
[24] https://www.eia.gov/naturalgas/U.S.liquefactioncapacity.xlsx
[25] https://cms.ferc.gov/media/north-american-lng-export-terminals-existing-approved-not-yet-built-and-proposed-8

Figure 4: DPL SOS procurement price history by auction year



Siemens, "Final Report of the Technical Monitoring Consultant on DPL 2023 FP-SOS RFP Presented to the Delaware Public Service Commission," March 8, 2023[26]

The Synapse BCA models this hypothetical 800 MW wind project installed by 2030 under four scenarios: 1) mid-gas price and conservative wind learning rate 2) mid-gas price and a moderate wind learning rate 3) high gas price and conservative wind learning rate and 4) high gas price and moderate wind learning rate. The wind learning rates affect cost and the gas prices affect benefits. Details about these scenarios are provided in Appendix B: BCA Modeling Methodology. The inputs and assumptions include costs and benefits such as avoided energy, capacity, REC, greenhouse gas emission and health costs. The model provides a framework for determining cost-effectiveness that should be revised and updated as new information becomes available.

The net present value impacts for Delaware from each of four scenarios is summarized in Tables 4 and 5 below.[27]

Table 4: Total costs and benefits (2022$/MWh)

Scenarios	Total Present Value Costs	Total Present Value Benefits	Net Present Value Impacts (Total Benefits – Total Costs)
Mid-price gas, conservative wind learning rate	$68	$53	-$15
Mid-price gas, moderate wind learning rate	$64	$53	-$11
High-price gas, conservative wind learning rate	$68	$71	$3
High-price gas, moderate wind learning rate	$64	$71	$7

The Synapse analysis finds that under two high-price gas scenarios, there are net benefits of $3/MWh and $7/MWh. Under the two mid-price gas scenarios, there are net costs of -$15/MWh and -$11/MWh.

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[26] Delaware Public Service Commission, https://depsc.delaware.gov/wp-content/uploads/sites/54/2023/03/Siemens-PTI-Final-Report-of-the-Technical-Consultant-on-DPL-2023-FP-SOS-RFP-DE-PSC-2_ver_1-1.pdf

[27] A BCA compares the sum of the present value of all the benefits (in dollars) to the sum of the present value of all the costs. The results of a BCA is reported in the form of (1) present values of costs and benefits, (2) net impacts, which involves subtracting the present value costs from the present value benefits, and (3) a benefit-cost ratio (BCR), which involves dividing the present value benefits by the present value costs. A net impact that is negative means the project is not cost effective and a present value net impact that is positive means the project is cost effective. Synapse calculated the present value costs, present value benefits, and present value net impacts in $/MWh.

Table 5: Breakout of benefits (2022$/MWh)

Scenarios	Energy Benefits	Capacity Benefits	REC Benefits	Carbon Benefits	Health Benefits	Total Benefits
Mid-price gas, conservative wind learning rate	$24	$4	$13	$7	$6	$53
Mid-price gas, moderate wind learning rate	$24	$4	$13	$7	$6	$53
High-price gas, conservative wind learning rate	$42	$3	$11	$9	$6	$71
High-price gas, moderate wind learning rate	$42	$3	$11	$9	$6	$71

Synapse also finds that:

- The largest source of benefits is energy benefits, representing 45 and 59 percent of total benefits for the mid and high gas price scenarios, respectively. The avoided energy costs represent the average avoided variable costs of the marginal resource in the PJM-EMAAC zone. The marginal resource is often a natural gas combustion resource but can vary on an hourly basis and therefore represents a blend of the various resources required to meet load.
- Capacity benefits are the lowest proportion of the total benefits (at roughly 7 and 5 percent of total benefits in the two cases) as offshore wind does not provide significant output during peak hours (e.g., summer afternoons)
- REC benefits comprise another 25 and 15 percent of the total benefits for the mid and high gas scenarios. To remove double counting, REC benefits represent the incremental REC benefits only. In other words, the REC benefits represent only the portion of these REC benefits that exceed the carbon benefits. In general, REC benefits are higher than carbon benefits as REC benefits accrue at a consistent rate of $25/MWh over time and for all MWhs generated.
- Carbon benefits represent a lesser proportion of benefits than RECs (13 percent for both cases), as carbon benefits accrue to a portion of the MWhs generated and this portion is declining over time as renewable energy represents a greater portion of supply.
- Health benefits represent 11 and 8 percent of total benefits for the two scenarios, respectively.

The macroeconomic impact analysis focuses only on impacts to the Delaware state economy and did not include benefits or costs flowing out of state. Synapse assumes there would be no specific policy interventions to promote the role of Delaware industry in the construction of new wind and transmission facilities beyond what would be expected given the current economic profile of the state and the proximity of Delaware to the envisioned offshore facility site. In this conservative approach, Synapse assumes that only 25 percent of the work in most categories would be located in Delaware. This is done to avoid overestimating the local job impacts in a regional industry.

This analysis considers direct, indirect, and induced impacts,[28] reporting changes in overall state employment, income, and gross domestic product (GDP).[29] This analysis considers four discrete types of changes in expenditures associated with the construction the facility:

- Incremental spending on offshore wind facility construction
- Incremental spending on land-based transmission construction
- Reduction in spending on generation operations and maintenance (O&M) at Delaware-based facilities
- Change in total utility bills, which affects customer spending patterns that in turn affect local macroeconomic development

[28] *Direct impacts* consist of the economic activity created from the direct investment in the project, including activity from the design and engineering, construction, operation, and maintenance of the project. *Indirect impacts* consist of the economic activity from the supply chain that is necessary to support the direct investment in the project. *Induced impacts* consist of the economic activity from employees in newly created direct and indirect jobs spending their paychecks locally on goods and services.

[29] Employment is reported in terms of *job-years*, each of which is equivalent to a full-time employment opportunity for one person for one year (e.g., five job-years could be five jobs for one year or one job for five years). The income results encompass the change in the total income collectively received by all individuals, businesses, and households in Delaware. Finally, the GDP measure corresponds to the change in the total monetary or market value of all the finished goods and services produced within Delaware.

Synapse does not analyze the economic impacts associated with ongoing operations and maintenance expenses on new transmission and offshore wind infrastructure since these impacts are expected to be quite small.

Ttable 6 below provides a summary of these impacts for each scenario. The table covers 2029-2050 (2 years construction, 20 years operation). To contextualize the magnitude of the projected impacts, Delaware's GDP in 2022 was $87.5 billion.[30] The strongest determinant of whether total scenario macroeconomic impacts are positive or negative is the net utility system impact, which is used to derive the electric bill impacts for all customers. Overall, Synapse finds positive overall impacts on total state employment, income, and GDP in the high-gas price scenarios and negative overall impacts on the same indicators in the mid-gas price scenarios.

Table 6: Summary of macroeconomic impacts

Scenarios	Employment (job-years)	Income (million$)	GDP (million$)
Mid-price gas, conservative wind learning rate	-7,549	-$394	-$848
Mid-price gas, moderate wind learning rate	-5,814	-$296	-$653
High-price gas, conservative wind learning rate	1,569	$137	$169
High-price gas, moderate wind learning rate	3,304	$235	$364

Higher gas prices would result in net bill savings for electric customers which drives overall positive changes in employment, income, and GDP over the entire modeled period. The narrow range of net costs or benefits shows that the overall value of OSW for Delaware is sensitive to further developments — which will require ongoing monitoring and analysis and points to those factors that Delaware will have to be mindful of in developing a procurement strategy.[31]

3.8 Environmental Considerations

A key component of the offshore wind planning process is identifying the potential environmental impacts and addressing ways to avoid, minimize, or mitigate these impacts to balance the uses and resources that are important to Delawareans. Although offshore wind may be beneficial in mitigating climate change, proposed development within the ocean should be carried out responsibly.

Offshore wind projects require extensive environmental reviews and permitting to ensure responsible ocean and associated onshore development. The DNREC Offshore Environmental Permitting Work Group (DOEP) was established in the Spring of 2022 to enhance communication within DNREC regarding offshore projects and to collaborate and coordinate on environmental permitting processes related to these types of activities. DOEP is coordinated and facilitated by DNREC's Coastal Management Program (DCMP) within the Division of Climate, Coastal and Energy.

The DCMP Is also responsible for federal consistency reviews pursuant to the federal Coastal Zone Management Act of 1972. Federal consistency requires that projects conducted directly by a federal agency, projects authorized by a federal license or permit, and some projects implemented with federal funds within the coastal zone be consistent with Delaware's approved Coastal Zone Management enforceable policies. Delaware's federal coastal zone encompasses the entire state of Delaware including state waters. Additionally, Delaware has an approved geographic location description for offshore alternative energy projects that allows the DCMP to review projects in federal waters 3-24 nautical miles off the coasts of New Jersey, Delaware and Maryland; beginning off New Jersey's coast at Hereford Inlet (BOEM lease blocks 7126-7136) extending south encompassing off shore areas of southern New Jersey,

[30] https://usafacts.org/metrics/gross-domestic-product-gdp-by-state-delaware/
[31] The Special Initiative on Offshore Wind identifies methods for controlling project costs in its report, Offshore Wind Procurement Options for Delaware

Delaware and Maryland, and terminating at the BOEM administrative boundary between Maryland and Virginia.

Additionally, Delaware has an approved interstate geographic location description for alternative energy facilities occurring in New Jersey within the Delaware River and Bay from Artificial Island to Cape May and state ocean waters from 0-3 nautical miles extending from Hereford Inlet south to the tip of Cape May; and in Maryland within state ocean waters from 0-3 nautical miles. Therefore, DNREC Coastal Management Program has the authority to review alternative energy projects off the coasts of Delaware, Maryland, and a portion of New Jersey. For projects with proposed landings and interconnection sites within Delaware, the DCMP could be able to review from the proposed offshore wind farm to the proposed interconnection point. These reviews are often coordinated with other permitting authorities within the Department, including but not limited to, the Division of Air Quality, the Division of Water, the Division of Watershed Stewardship, and the Division of Waste and Hazardous Substances in addition to other state agencies such as the Delaware Department of State, Division of Historical and Cultural Affairs.

The importance of coordination among agencies is equally applicable at the regional and federal level. Offshore wind energy is a relatively new use of the oceans and outer continental shelf lands off the U.S. coasts. As with any new venture, there are often information gaps that need to be considered. Addressing data gaps and engaging stakeholders early in the process supports transparency and streamlines processes by providing data that is often necessary to make informed decisions. Although regional information certainly supports decision making, state specific baseline data is also necessary. To address these environmental data gaps, other states in the region have engaged with stakeholders and conducted literature reviews and environmental studies as part of similar strategic planning efforts. The New York State Offshore Wind Master Plan is a comprehensive roadmap and suite of more than 20 studies for the first 2,400 megawatts of offshore wind energy that encourages the development of offshore wind in a manner that is sensitive to environmental, maritime, economic, and social issues while addressing market barriers and aiming to lower costs.[32] Similarly, the New Jersey Offshore Wind Strategic Plan dedicated a chapter to environmental and natural resources protection and provided specific recommendations to minimize impacts to the state's natural resources. New Jersey also addressed potential impacts to other users, such as commercial and recreational fisheries.[33] Additionally, in their second solicitation for offshore wind, New Jersey required project developers to contribute $10,000 per megawatt to fund environmental research initiatives and fisheries monitoring in the region.[34]

[32] https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/About-Offshore-Wind/Master-Plan
[33] https://www.nj.gov/bpu/pdf/Final_NJ_OWSP_9-9-20.pdf
[34] https://www.njcleanenergy.com/renewable-energy/programs/nj-offshore-wind/solicitations

4.0 Procurement Planning

A procurement strategy for Delaware needs to carefully consider scale, structure (PPA, OREC or other structure), and the need to adapt to changing industry conditions.

4.1 Meeting Delaware's Renewable Energy Needs

A key difficulty for Delaware and other states in procurement planning is the mismatch between optimal offshore wind scale and Delaware's buying power. Delaware would need about 800 MW of offshore wind (the amount modeled in the SIOW report[35]) to meet its RPS obligations for all utilities by 2035. Recent developments have highlighted the need for a more coordinated and efficient buildup of the offshore wind industry. While the procuring authority is established at the state level, there is increasing recognition of the inefficiencies of a state-by-state approach and the need to work across state lines in procurement, economic development, workforce development, and transmission.

Several benefits may arise out of cooperative approach with other states to procure offshore wind resources jointly. These benefits may include market predictability, economies of scale, standardization, and innovation. A consortium of states working collaboratively could give the offshore wind industry more predictability if there are firm procurements across several states. Predictability would support investment decisions for developers and the offshore wind supply chain. Suppliers would benefit from market certainty for components and services. A predictable offshore wind market would also encourage innovative solutions since stakeholders would know that future projects will occur rather than plan for one-off projects. A cooperative approach may also foster economies of scale since multiple jurisdictions may combine projects that could lower component costs compared to a smaller sized project targeting a single jurisdiction. That in turn may help reduce cost impacts for ratepayers compared to single projects developed sequentially. A cooperative approach may also result in the standardization of bids and the review of bids. That could help streamline the approval process for projects. Finally, a cooperative approach may help foster innovation within the industry, since the positive attributes of predictability, scale, and standardization may convince parties to look at solutions to address multiple projects rather than single projects.

Rhode Island's negotiation and approval of the 400 MW Revolution Wind offshore wind power purchase agreement (PPA) is an example of one state utilizing another state's offshore wind procurement process. On June 29, 2017, Massachusetts issued a Request for Proposal (RFP) for offshore wind energy projects.[36] The Massachusetts RFP included a provision for both Rhode Island and Connecticut to consider and evaluate proposals. Through the Massachusetts RFP process, Rhode Island was able to negotiate and approve a power purchase agreement with Deepwater Wind, now Ørsted, for the Revolution Wind project in 2019. In 2018, Connecticut approved a separate power purchase agreement for 304 MW from Deepwater Wind for it. Delaware should look for similar opportunities in possible upcoming Maryland and New Jersey offshore wind solicitations to procure incremental amounts of offshore wind. This approach could allow Delaware to participate in more favorable pricing as part of a larger solicitation rather than creating a Delaware specific procurement solicitation.

In October 2023, Connecticut, Massachusetts, and Rhode Island signed a memorandum of understanding (MOU) to codify offshore wind procurement collaborations among the three states.[37] The MOU formalizes the consideration of joint procurements like the 2017 Massachusetts RFP. Elements of the MOU include participation of other states' EDCs in solicitation, good faith approach to include multi-state bids, the encouragement of multi-state bids, and multi-state bids offer at same price to all states.

[35] Special Initiative on Offshore Wind, Offshore Wind Procurement Options for Delaware

[36] https://macleanenergy.files.wordpress.com/2017/02/section-83c-request-for-proposals-for-long-term-contracts-for-offshore-wind-energy-projects-june-29-2017.pdf

[37] https://portal.ct.gov/-/media/DEEP/energy/Procurements/MARICT-Offshore-Wind-Procurement-Collaboration-Memorandum-of-Understanding--Final-10323-CEM-Sig.pdf

The MOU does allow for severable commitments (economic development in specific locations) for each of the three states.

On June 23, 2022, the White House launched the Federal-State Offshore Wind Implementation Partnership, involving four federal agencies (Department of Energy, Department of Interior, Department of Commerce, and Department of Transportation) and 11 states, including Delaware.[38] The goal of the partnership is to expand federal and state collaboration to expand key elements of the offshore wind supply chain that includes manufacturing facilities, port capabilities, and workforce development.[39] The Partnership released a Memorandum of Understanding (MOU) that outlines that the parties will define a collaborative framework to establish an efficient and sustainable offshore wind supply chain that minimizes gaps across the sub-region, while meeting the goals of each state associated with economic development, workforce development, and environmental justice.[40] The MOU also identifies several high priority supply chain gaps that include, but are not limited to: Jones Act compliant vessels, port development, and expanded US steel production.[41] Federal agencies will help provide technical support to the partnership states and will help the partner states develop and share comprehensive procurement and leasing timelines.

European countries have also taken similar steps to increase collaboration among countries. In November 2023, the North Seas Energy Cooperation (Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden, and the European Commission) announced the agreement of a tender schedule across the nine partner countries.[42] The published schedule codifies the procurement of approximately 72,000 MW of offshore wind from 2024 through 2030 and also outlines the construction schedule for the 72,000 MW through 2038. While it is not clear that all of the projects listed will be completed, the detailed plan does outline what projects may occur in the North Seas over the next 15 years to provide visibility on project demand.

Delaware is participating in the SMART-POWER collaborative with MD, VA and NC. SMART-POWER has engaged the National Renewable Energy Laboratory (NREL) to study supply chain and workforce development opportunities and constraints relating to the offshore wind procurements of the four states. This study is emphasizing a conservative approach to supply chain opportunities that does not assume large “Tier 1” projects such as a turbine blade or gearbox manufacturing facility locating in the region, but instead is focusing on those components or services that are more likely to be more cost effective for the next generation of offshore wind projects in the region. The collaborative will also inventory workforce development programs in the four states to hopefully avoid inefficient duplication of training programs. This conservative approach is built into the benefit/cost analysis, which uses modest assumptions on the employment benefits for a Delaware offshore wind project.

4.2 Procurement Structure

Offshore wind procurements in the U.S. have followed one of two basic approaches: the OREC (Offshore Wind Renewable Energy Credit) or the PPA (power purchase agreement). New York, New Jersey, and Maryland are using ORECs. PPAs are prevalent in the New England states. An OREC is the environmental attribute associated with one megawatt-hour of electricity generated from an eligible offshore wind project that can be used to fulfill a state’s renewable portfolio standard requirements. ORECs generally include energy, capacity, ancillary services, and environmental attributes. A 2020 National Renewable Energy Laboratory report describes different OREC structures.[43] The NREL report notes that the OREC structure involves the wind generator selling energy and capacity into the wholesale

[38] Available at: https://www.whitehouse.gov/wp-content/uploads/2023/09/Federal-State-MOU-on-East-Coast-Offshore-Wind-Supply-Chain-Collaboration.pdf
[39] Ibid.
[40] Ibid. Page 4.
[41] Ibid. Page 4.
[42] https://energy.ec.europa.eu/document/download/95a9abc5-aa53-41a3-8330-4aa70381b2ed_en?filename=231117%20NSEC%20tender%20planning%20-%20November%202023_0.pdf
[43] Beiter, P., Heeter, J., Spitsen, P., Riley, D. Comparing Offshore Wind Energy Procurement and Project Revenue Sources Across the U.S. States. NREL/TP-5000-76079. June 2020. Page 24.

market. The associated revenues are then routed to an escrow account or administrator. Similarly, the electric distribution utility collects OREC payments from ratepayers and then routes the collected fees to the escrow account or administrator. The escrow account pays the developer the OREC amount. Ratepayers would be credited with the wholesale energy and capacity revenues generated by the developer.

A PPA is a standardized long-term contract, typically lasting 20 years, for the purchase of energy, capacity, energy services and/or environmental attributes from a specific renewable energy generator. Offshore wind PPAs are currently used in Massachusetts, Rhode Island, Connecticut, and Maine.[44] The 2020 NREL report states that offshore wind generators in these states generally sell energy, energy services, and/or RECs to the electric distribution utility, which then sells the energy in the wholesale market and RECs to the electricity supplier. Under the PPA agreement, the offshore wind developer receives a fixed price ($/MWh) for generation regardless of the market clearing price. In an energy only PPA, the developer is free to sell the project's capacity into the wholesale market outside the PPA structure. The PPA structure contractual joins the developer with the electric distribution utility with the state approving the PPA price for ratepayers.

Further analysis, in collaboration with utilities, the Public Service Commission, and the Public Advocate, is advisable before deciding which structure is best suited for Delaware.

4.3 Structuring Procurement to Adapt to Market Conditions

A procurement strategy should include the flexibility to incorporate new information, analysis, and developments along the way. Some key upcoming developments are summarized in Table 7 below.

Table 7: Key upcoming developments

Milestone	Subject	Timeline
PJM's Phase 2 Offshore Wind Transmission Study	Includes requested analysis of 1,000 MW connecting into Delaware	TBD
BOEM lease of new WEAs	New WEAs identified; lease auctions announced	Dec. 2024, future WEAs TBD
NREL OSW component costs study	Updated study of the cost of key OSW components	Q2 2024
Northeast States Offshore Wind Transmission Collaboration	Longer term study of transmission planning options for east coast OSW	Ongoing
SMART-POWER Collaborative	Regional (DE, MD, VA, NC) supply chain and workforce development analysis	Q4 2024
Develop closer coordination with neighboring states	Collaboration and coordination on transmission, procurement, supply chain development, and workforce development.	Ongoing
Consultation with Delaware electric utilities and agencies	Procurement design, such as ORECs or PPAs, stand-alone or coordinated procurement	Starting Q1 2024

These developments will provide useful, and even critical milestones along the way. The proposed procurement plan should allow for flexibility and adjustments in response to information gained as we track progress along these mileposts. With this report, DNREC is drafting model legislation to establish a path forward on offshore wind procurement.

[44] Ibid. Page 54.

5.0 Recommendations

This report comes at a time of considerable uncertainty in the offshore wind industry, and in energy markets more generally. In reviewing these changing conditions, key factors, and anticipated developments coming up in 2024, the importance of flexibility cannot be overemphasized.

With these uncertainties in mind, DNREC submits these overarching recommendations:

1. Delaware should proceed with legislation authorizing the procurement of offshore wind to serve Delaware, either as a standalone project or in partnership with other states.
2. DNREC should prepare model legislation to establish a path forward on offshore wind procurement that best serves the needs of Delaware.
3. DNREC should be the lead agency in developing an offshore wind procurement program.
4. The procurement program should encompass as much flexibility (in terms of timing, scale, location, and agreement structure) as possible to best adapt to changing industry conditions.
5. The procurement program should be developed in consultation with all Delaware utilities, mindful of their differing governance structures and business practices.
6. The procurement program should maximize long-term value and minimize ratepayer impacts.
7. The procurement program should provide for economic development and workforce development without adding specifications that would drive up the cost.
8. The procurement program should include possible partnerships with neighboring states on subjects including procurement, transmission, and supply chain development to take advantage of economies of scale beyond those of Delaware's buying capacity.
9. The procurement program should be structured to promote the coordinated, cost-effective buildout of the transmission system on a regional scale.
10. The procurement program should consider potential environmental and natural resource impacts and include ways to avoid, minimize, or mitigate these impacts in planning for offshore wind procurement.
11. DNREC should update its analysis and adapt this strategy on an ongoing basis as more information becomes available.

In developing and implementing an offshore wind procurement program, DNREC should not rely on what other states have done but focus on what works best for Delaware. This will require ongoing analysis and planning to ensure that ratepayers costs, other economic impacts, public health, and climate impacts are all given their due consideration. Concurrent with this report, DNREC is preparing model legislation to establish a path forward on offshore wind procurement that incorporates the need for flexibility and ongoing analysis. DNREC looks forward to working with utilities, the Public Service Commission, the Public Advocate, PJM, the General Assembly, and other stakeholders, and on crafting a path forward on procurement that can best meet Delaware's particular circumstances and energy needs.

Acronyms

BOEM	Bureau of Ocean Energy Management
CAP	Climate Action Plan
CO2	Carbon Dioxide
DEC	Delaware Electric Cooperative
DEMEC	Delaware Municipal Electric Corporation
DNREC	Delaware Department of Natural Resources and Environmental Control
DOE	(U.S.) Department of Energy
DPL	Delmarva Power & Light
DPA	Delaware Public Advocate
PSC	Delaware Public Service Commission
FERC	Federal Energy Regulatory Commission
GEAC	Governor's Energy Advisory Council
GEF	Green Energy Fund
GHG	Greenhouse gas
kW	Kilowatt, a measure of power equal to 1,000 watts
kWh	Kilowatt hour, the amount of energy consumed by using one kW of power for one hour
LCOE	Levelized cost of energy; the average cost of energy over time in current dollars
MW	Megawatt, a measure of power equal to 1,000 kilowatts
MWh	Megawatt hour, the amount of energy consumed by using one MW of power for one hour
NM	Nautical mile
NOx	Nitrogen oxides
OREC	Offshore Wind Renewable Energy Credit
OSW	Offshore Wind
PJM	PJM Interconnection, LLC; the regional grid operator serving Delaware and the Mid-Atlantic region
PPA	Power Purchase Agreement
PSC	Public Service Commission
REC	Renewable Energy Credit
REPSA	Renewable Energy Portfolio Standards Act; 26 *Del.C.* Chapter 1. Subchapter III-A; Delaware's renewable energy law
RETF	Renewable Energy Taskforce
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
SAA	State Agreement Approach
SIOW	Special Initiative on Offshore Wind
SO2	Sulphur dioxide
SREC	Solar Renewable Energy Credit
WEA	Wind Energy Area; an area of federal waters designated by the Bureau of Ocean Energy Management (BOEM) for offshore wind development

Glossary

Capacity
The maximum amount of electricity a generator can produce, measured in megawatts (MW).
Climate Change
A long-term change in the average weather patterns that have come to define Earth's local, regional and global climates.
Delaware Energy Office
The State Energy Office is located in DNREC's Division of Climate, Coastal and Energy.
Electrification
The process of replacing technologies that use fossil fuels as an energy source with technologies that use electricity instead. Electrification holds to the expectation that electricity is generated using clean or renewable energy.
Federal Energy Regulatory Commission (FERC)
FERC has jurisdiction over the interstate sale and transmission of electricity and natural gas and regulates PJM.
Green Energy Fund
A fund to provide financial support for renewable energy in Delaware, funded by a small rate surcharge on customer bills. Each utility manages its own Green Energy Fund.
Greenhouse Gases
Gases in the atmosphere that have the ability to trap heat. Common greenhouse gases include carbon dioxide, methane, nitrous oxide, certain fluorinated gases (such as hydrofluorocarbons and chlorofluorocarbons) and water vapor.
Federal Energy Regulatory Commission (FERC)
FERC has jurisdiction over the interstate sale and transmission of electricity and natural gas and regulates PJM.
Greenhouse Gases
Gases in the atmosphere that have the ability to trap heat. Common greenhouse gases include carbon dioxide, methane, nitrous oxide, certain fluorinated gases (such as hydrofluorocarbons and chlorofluorocarbons) and water vapor.
Kilowatt (kW)
A kW is a unit of electrical capacity equal to 1,000 watts.
Kilowatt-hour (kWh)
A kWh is a unit of electrical energy equal to 1,000 watt-hours.
Megawatt (MW)
A MW is a unit of electrical capacity equal to 1,000 kilowatts or 1,000,000 watts.
Megawatt-hour (MWh)
A MWh is a unit of electrical energy equal to 1,000 kWh.
Peak Demand
The highest electric power demand that has occurred over a specified time period.
PJM Interconnection
PJM is the regional transmission organization responsible for planning and operating the electric transmission grid across thirteen Mid-Atlantic and Midwestern states and the District of Columbia. PJM also administers the wholesale power markets in its territory to assure bulk system reliability.
Renewable Energy Credits (RECs)
A REC represents the environmental attributes of 1 MWh of electricity from a renewable resource.
State Agreement Approach (SAA)
A transmission planning process in which one or more states develops an agreement with PJM, including cost allocation, in order to meet state policy goals.

Appendix A: Status of Select Offshore Wind Projects Along Eastern Seaboard

Lease Location	Project Name	Developer	Project Size (MW)	Contracting Arrangement	Announced COD	Current Status
RI	Block Island	Ørsted	30	PPA-RI	2016	Operational
VA	Coastal Virginia Offshore Wind (Pilot)	Dominion Energy	12	Utility Owned-VA	2020	Operational
Subtotal Operational			**42**			
MA	Vineyard Wind	Avangrid	800	PPA-MA	2024	Under Construction
RI/MA	South Fork Wind Farm	Ørsted/Eversource	132	PPA-NY	2024	Under Construction
RI	Revolution Wind	Ørsted/Eversource	704	PPA-RI & CT	2026	FID
Subtotal Under Construction & FID			**1,636**			
ME	New England Aqua Ventus 1	U. of Maine/ Diamond Offshore/RWE	12	PPA-ME	2024	Permitting
NY	Empire Wind 1	Equinor Wind US/BP	816	OREC-NY	2026	Permitting
NY	Empire Wind 2	Equinor Wind US/BP	1,260	OREC-NY	2027	Permitting
NJ	Atlantic Shores Offshore Wind South, Project 1	EDF/Shell	1,510	OREC-NJ	2027	Permitting
NJ	Atlantic Shores Offshore Wind South, Project 2	EDF/Shell	890	TBD	TBD	Permitting
MD	MarWin	US Wind	270	OREC-MD	2025	Permitting
MD	Momentum Wind	US Wind	809	OREC-MD	2028	Permitting
MD	MarWin (Residual)	US Wind	600	TBD	TBD	Permitting
VA	Coastal Virginia Offshore Wind (CVOW)	Dominion Energy	2,587	Utility Owned-VA	2026	Permitting
Subtotal Under Permitting			**8,754**			
MA	Beacon Wind 1	Equinor Wind US/BP	1,230	OREC-NY	2029	Possible Rebid
MA	Beacon Wind 2	Equinor Wind US/BP	1,200	TBD	TBD	Possible Rebid
DE	Skipjack 1	Ørsted	120	OREC-MD	2026	Work Stopped
DE	Skipjack 2	Ørsted	846	OREC-MD	2027	Work Stopped
Subtotal Under Possible Rebid/Work Stopped			**3,396**			
ME	Maine Research Array		144	TBD	TBD	Planning
MA	Vineyard Northeast	Avangrid	2,143	TBD	TBD	Site Control
RI/MA	Bay State Wind	Ørsted	2,000	TBD	TBD	Site Control
NY/NJ	Vineyard Mid-Atlantic	Avangrid	697	TBD	TBD	Site Control
NY/NJ	Bluepoint Wind	EDPR/ENGIE	1,158	TBD	TBD	Site Control

Lease Location	Project Name	Developer	Project Size (MW)	Contracting Arrangement	Announced COD	Current Status
NY/NJ	Attentive Energy	Total Energies	1,365	PPA-NY	TBD	Site Control
NY/NJ	Community Offshore Wind	RWE/National Grid	2,039	PPA-NY	TBD	Site Control
NY/NJ	Atlantic Shores Offshore Wind Bight	EDF/Shell	1,284	TBD	TBD	Site Control
NY/NJ	Leading Light Wind	Invenergy	1,359	TBD	TBD	Site Control
NJ	Atlantic Shores Offshore Wind North	EDF/Shell	1,182	TBD	TBD	Site Control
DE	Garden State Offshore Energy	Ørsted	1,080	TBD	TBD	Site Control
Subtotal Under Possible Planning/Site Control			**14,451**			
MA	Commonwealth Wind	Avangrid	800	PPA-CT	2027	Withdrawn
MA	Commonwealth Wind	Avangrid	1,232	PPA-MA	2027	Withdrawn
MA	SouthCoast Wind 1a	Shell/ EDPR/ENGIE	804	PPA-MA	2028	Withdrawn
MA	SouthCoast Wind 1b	Shell/ EDPR/ENGIE	400	TBD	2029	Withdrawn
MA	SouthCoast Wind (Residual)	Shell/ EDPR/ENGIE	800	TBD	TBD	Withdrawn
RI/MA	Revolution Wind II	Ørsted/Eversource	884	OREC-NY	2026	Withdrawn
RI/MA	Park City Wind	Ørsted/Eversource	800	OREC-NY	2026	Withdrawn
NJ	Ocean Wind 1	Ørsted	1,100	OREC-NJ	2025	Withdrawn
NJ	Ocean Wind 2	Ørsted	1,148	OREC-NJ	2028	Withdrawn
Subtotal Withdrawn			**7,968**			
Total All Projects			**36,247**			

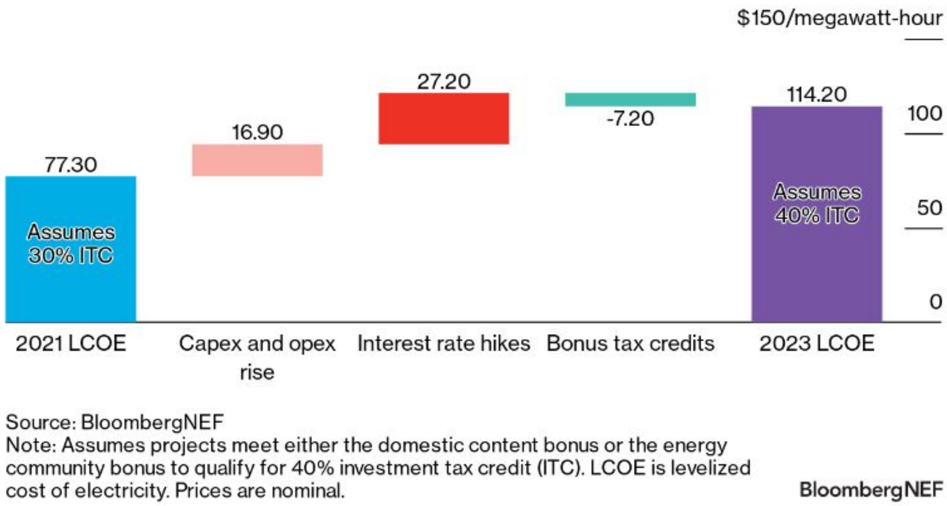
Notes
Adapted and updated from DOE Offshore Wind Market Report: 2023 Edition, Tables 3 and 4
Updated from company and regulator announcements
COD: Commercial Operation Date
FID: Final Investment Decision
PPA: Power Purchase Agreement
OREC: Offshore Wind Renewable Energy Credit
TBD: To be determined

Appendix B: BCA Modeling Methodology

In its BCA, Synapse assumes the project is installed over the course of two years (in 2029 and 2030),is fully operational starting in 2031, and has a measure life of 20 years.. Synapse reports all results in 2022-year dollars, converts year dollars using the GDP Deflator from the Federal Reserve Bank of St. Louis, and applies a real discount rate of 3 percent to determine the present value costs and benefits.

Synapse derives offshore wind costs from the Bloomberg New Energy Finance blog titled “Soaring Costs Stress U.S. Offshore Wind Companies, Ruin Margins” from August 1, 2023. This source provides the levelized cost associated with a utility-scale fixed bottom offshore wind system installed in 2023 of $114/MWh as shown in the purple bar in the figure below. This, like other key inputs, should be considered provisional as NREL is expected to update its study of OSW component costs in 2024.

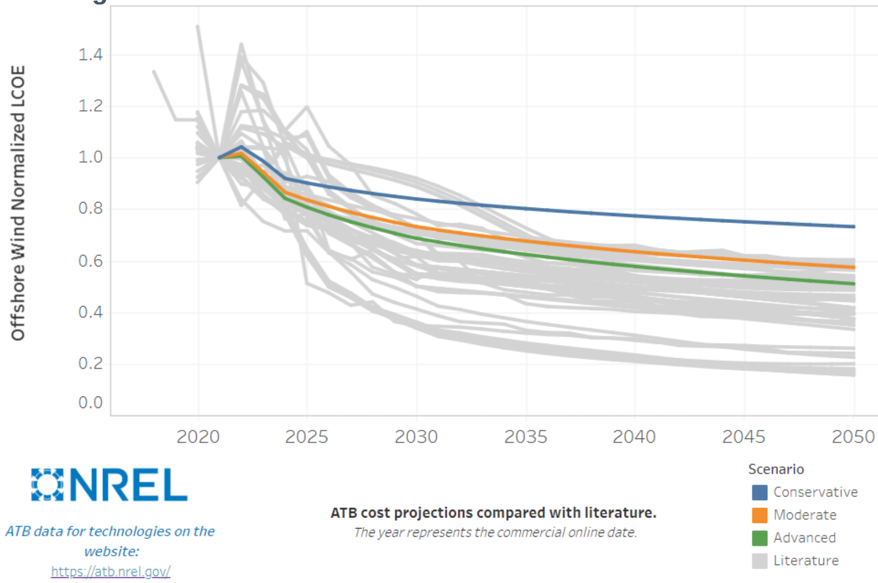
Figure 5. Impact of inflation, interest rates, and tax credits on U.S. offshore wind LCOEs



Source: Bloomberg New Energy Finance (BNEF). “Soaring Costs Stress U.S. Offshore Wind Companies, Ruin Margins.” August 2023. Available at: https://about.bnef.com/blog/soaring-costs-stress-us-offshore-wind-companies-ruin-margins/

Synapse applies two wind learning rates from NREL’s 2023 Annual Technology Baseline (ATB) to these costs to reflect expected technological progress and economies of scale a between 2023 and 2030. The figure below shows the cost trajectory for the conservative case in blue and the moderate case in orange. The conservative wind learning rate assumes a cost reduction of 17.6 percent and the moderate wind learning rate assumes a cost reduction of 22.2 percent. The levelized cost, adjusted to 2022-year dollars and the two wind learning rates, is $91/MWh with the conservative wind learning rate and $86/MWh with the moderate wind learning rate. The cost estimates include both onshore and offshore transmission costs, which are a portion of the total costs.

Figure 6. Wind learning rate scenarios



Source: National Renewable Energy Laboratory (NREL). 2023 Annual Technology Baseline (ATB). Offshore Wind. Available at: https://atb.nrel.gov/electricity/2023/offshore_wind#:~:text=In%20the%202023%20ATB%2C%20each,%2C%20wind%20speed%2C%20and%20costs.

Synapse then multiplies the offshore wind energy generation in each year from 2031 to 2050 by the levelized cost per MWh to calculate project costs in each year and calculates the present value of the stream of annual project costs over the project's assumed lifetime.

Synapse also calculates project benefits in each year and the present value of the stream of annual project benefits over the project's assumed lifetime. For avoided energy and capacity costs, Synapse relies upon capacity-expansion and production-cost modeling of PJM developed in the EnCompass power planning software.

The model represents the electric grid using a set of zones and transmission connections between those zones. Synapse focuses on the planning and operation of the PJM-EMAAC locational delivery area and assumes transmission within a zone is unrestricted but transmission between zones is limited. PJM-EMAAC includes portions of New Jersey (PSE&G, JCP&L, AE, and RECO), portions of Pennsylvania (PECO), portions of Maryland, and all of Delaware (DPL). For the mid gas price scenario, Synapse applies a capacity-expansion scenario to produce a set of resources to optimally meet load and peak demand over the 2023 through 2033 timeframe, and then simulates hourly dispatch for the years of 2030 to 2033. Only the dispatch is updated for the high gas price scenario.

The avoided energy cost assumptions for 2030 through 2033 (in $/MWh) are based on EnCompass marginal energy price outputs, as the marginal energy price is what would be required to meet the next increment of load. The temporal granularity is 8,760 hours per year for each of the four years. The avoided capacity cost assumptions for 2030 through 2033 (in $/MW-year) are based on EnCompass capacity price outputs for the PJM-EMAAC zone. Synapse then extends the avoided energy and capacity cost values from 2034 through 2050 for the mid and high gas price scenarios using two trend lines interpolated from 2022 Cambium forecasted locational marginal prices for the PJM-EMAAC region (Scenario 1 for the mid gas price scenario and Scenario 8 for the high gas price scenario). [45]

Regarding energy and capacity requirements, the baseload, energy efficiency, distributed solar, and electrification forecasts are from PJM. Synapse assumes that all coal and gas plants currently listed as

[45] National Renewable Energy Laboratory (NREL). 2022. Energy Analysis. Cambium. Available at: https://www.nrel.gov/analysis/cambium.html.

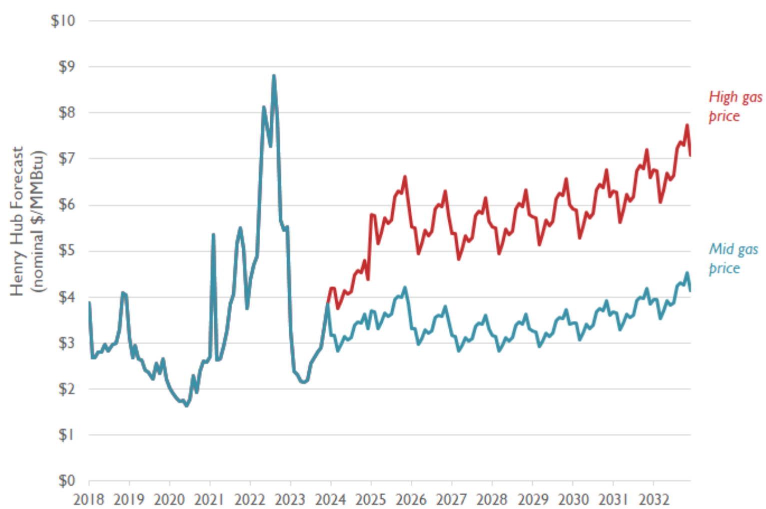
having an announced retirement retire no later than that date, allowed plants to retire endogenously as they became uneconomic, assumed nuclear plants receive license extensions, and assumed that *Inflation Reduction Act* (IRA) tax credits prevented nuclear plants from retiring. Synapse also assumes PJM capacity market demand curves, as well as local capacity requirements in PJM's EMAAC region.

Synapse relies on Horizons Energy's National Database[46] for our offshore wind load shape assumptions in EnCompass of 12 percent for summer peak, 16 percent for summer off-peak, 32 percent for winter peak, and 40 percent for winter off-peak. The annual capacity factor for offshore wind of 43 percent and the average effective load carrying capacity (ELCC) value of 28.3 percent for offshore wind in 2031 are from PJM.[47] Synapse decreases the average offshore wind ELCC value over time to 15 percent in 2050 due to the expectation that PJM will adopt a seasonal ELCC accreditation framework consistent with neighboring RTOs such as those in New York and New England.[48]

EnCompass calculates energy and capacity prices in 2030 assuming quantities of offshore wind that are currently under contract. The model includes roughly 11,000 MW of offshore wind capacity interconnected to PJM by 2030. In the PJM-EMAAC region specifically, the model includes 5,700 MW of offshore wind capacity by 2030. These amounts do not include any additional offshore wind projects that have not yet been announced and may come online between now and 2033 to meet state RPS and Clean Energy Standard targets. Ørsted recently announced it was cancelling both of its Ocean Wind projects off the coast of southern New Jersey due to financial challenges. These plants remain in the resource mix.

Synapse forecasts near-term natural gas prices based on NYMEX's Henry Hub Futures and blended these with U.S. Energy Information Administration (EIA) 2023 *Annual Energy Outlook* mid and high natural gas prices to produce two longer-term forecasts as shown in the figure below.[49]

Figure 7. AEO 2023 mid and high gas price trajectories



Source: U.S. Energy Information Administration (EIA). 2023 Annual Energy Outlook.

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[46] Horizons Energy. ND. National Database. Available at: https://www.horizons-energy.com/data/.

[47] PJM. February 24, 2023. *Energy Transition in PJM: Resource Retirements, Replacements & Risks*. Figure 5. Effective Load Carrying Capability (ELCC) Rating by Resource Type. Page 14. Available at: https://www.pjm.com/-/media/library/reports-notices/special-reports/2023/energy-transition-in-pjm-resource-retirements-replacements-and-risks.ashx.

[48] NREL. January 2020. *The Potential Impact of Offshore Wind Energy on a Future Power System in the U.S. Northeast.* Table 7. Capacity Credit Estimates for Combined ISO-NE and NYISO System using Top 100 Peak Net Load (Pre-Offshore Wind) Hours Methodology. Page 22. Available at: https://www.nrel.gov/docs/fy20osti/74191.pdf.

[49] U.S. Energy Information Administration (EIA). 2023 Annual Energy Outlook. Available at: https://www.eia.gov/outlooks/aeo/.

Synapse bases costs for new natural gas resources from AEO 2022 and adjusts them by U.S. Environmental Protection Agency's (EPA) regional cost factors.

Synapsed produces renewable costs by adjusting values from NREL's 2023 Advanced Technology Baseline (ATB) by EPA's regional cost factors.[50,51] NREL's newest forecast shows generally higher costs for all renewables due to policy and market condition changes since 2022 (2022 ATB costs were low because they came out before the recent wave of inflation). It is important to note that the avoided costs for new resources do not fully capture the recent price increases caused by inflation and higher interest rates.

Synapse uses the Horizons National Database assumptions to determine whether renewable energy projects choose the production tax credit (PTC) or the investment tax credit (ITC) and assumes that:

- Offshore wind, utility-scale solar, and utility-scale battery (4- and 8-hour) projects built through 2032 choose an ITC of 30 percent of capital investment and qualify for a 10 percent domestic content adder. Projects post-2032 do not receive the ITC.
- Onshore wind projects choose a PTC of $28/MWh and receive a domestic content adder of 10 percent, which increases the value to $30.50/MWh.

Synapse did not model natural gas with carbon capture and sequestration (CCS), coal with CCS, distributed storage, and advanced nuclear reactors and small modular reactors (SMRs) and held existing demand response constant over time.

Regarding policy requirements such as renewable portfolio standards (RPS), many northeastern states have RPS and clean energy standard policies that will incentivize renewable deployment between 2023 and 2030. Synapse incorporated=s the latest available data on RPS and clean energy standard requirements in each state and account for the eligible resource types in each state's RPS or clean energy standard as well as the fraction of the state's load that is subject to the policy. Synapse's analysis aggregates RPS programs for each RTO that combine the state RPS targets and reflect how states often accept RECs from nearby states in their RPSs. The analysis includes the RPS requirement for utility solar, wind, and biomass and fixes the carveouts for distributed solar, waste coal, and pumped hydro contributions. Regarding the Regional Greenhouse Gas Initiative (RGGI), Synapse assumes all current participants of RGGI remain participants and achieve their targets (Virginia continues to participate in RGGI and Pennsylvania remains a non-participant).

Regarding Renewable Energy Credits (RECs), Synapse assumes that the offshore wind project can avoid the need to purchase RECs. The analysis removes any duplication between the benefits captured by the social cost of carbon and the avoided REC cost. There is duplication because the RECs represent a monetization of a portion of the social cost of carbon. The avoided REC costs (assuming the maximum compliance cost of $25/MWh) is higher than the avoided carbon costs as the greenhouse gases emitted by the electricity grid drop over time due to the increasing stringency of RPS policies in the region. As a result, Synapse includes the full avoided carbon costs and only the incremental avoided REC cost s (the difference between the avoided REC costs and avoided carbon costs).[52]

The social cost of carbon is based on a December 2020 guideline document titled *Establishing a Value of Carbon* from the New York State Department of Environmental Conservation (the 2020 NYS SCC Guideline).[53] which recommends using the values identified as an interim SCC by the Biden

[50] NREL. *2023 Advanced Technology Baseline*. Available at: https://atb.nrel.gov/electricity/2023/index.

[51] U.S. EPA. September 2021. *Documentation for EPA's Power Sector Modeling Platform v6. Using the Integrated Planning Model.* Table 4-14. Regional Cost Adjustment Factors for Conventional and Renewable Generating Technologies in v6. Page 4-25. Available at: https://www.epa.gov/system/files/documents/2021-09/epa-platform-v6-summer-2021-reference-case-09-11-21-v6.pdf

[52] DSIRE. 2022. *Delaware Renewables Portfolio Standard Program Overview*. Available at: https://programs.dsireusa.org/system/program/detail/1231/renewables-portfolio-standard

[53] New York State Department of Environmental Conservation. 2020. *Establishing a Value of Carbon: Guidelines for Use by State Agencies.* Available at: https://www.dec.ny.gov/docs/administration_pdf/vocfguid.pdf.

Administration in February 2021 (and previously issued by the Obama Administration in 2016), but with a central discount rate of no more than 2 percent for decision-making. The 2031 value for this SCC is $139 per metric ton in 2020 using a 2 percent real discount rate, increases over time, andis held constant from 2045 to 2050.

Regarding avoided carbon emissions, EnCompass provides generation and the associated reductions in carbon emissions in short tons for 2030 through 2033 for each period and each scenario (i.e., the mid and high gas price scenarios). Synapse uses these outputs to calculate an annual avoided carbon emissions rate in short tons/MWh for each period through 2033 and decreases these emissions factors linearly to zero by 2050.

Regarding avoided health costs, EnCompass provides emissions reductions in NOx and SO2 in short tons for 2030 through 2033 for each period. SO2 has emissions reductions of zero since coal is the only type of resource that emits SO2 and coal is not present in PJM-EMAAC. Synapse divides these reductions by the energy produced by the wind farm in each period to generate annual NOX and SO2 emissions rates in short tons/MWh for each period. Emissions rates for PM2.5 are from U.S. EPA.[54] Synapse decreases these emissions factors linearly to zero by 2050. The avoided cost per short ton for NOX, SO2, and PM2.5 reflect the maximum annual Delaware-specific NOx, SO2, and PM2.5 damage estimates developed by the Center for Air, Climate and Energy Solutions using AP2/EASIUR/InMAP models.

EnCompass estimates avoided costs at the wholesale level, meaning reductions at power plants or energy markets. Retail avoided costs represent reductions at the customer meter or end-use level, and are meant to approximate the price customers see on utility bills. Synapse grosses up the wholesale avoided costs by a wholesale risk premium of 8 percent, leading to retail avoided costs that are greater than wholesale values. This analysis assumes no marginal energy (transmission and distribution) losses and no marginal peak demand (transmission and distribution) losses as the project interconnects directly to the onshore transmission system. The wholesale risk premium is the same for avoided wholesale energy prices and avoided wholesale capacity prices. The wholesale risk premium is not applied to non-embedded values such as carbon because, by definition, these costs are not embedded in electricity prices (therefore retail suppliers do not include these costs in supply contracts). The wholesale risk premium also does not apply to cleared capacity values because resources cleared in the FCM receive FCM prices.

Synapse multiplies the offshore wind generation in each year from 2031 to 2050 by the avoided energy, REC, carbon, and health cost per MWh to calculate energy-related benefits in each year and the net present value of the benefits in aggregate over the project's lifetime. The offshore wind capacity in each year from 2031 to 2050 is multiplied by the avoided capacity cost per MW to calculate capacity-related benefits in each year and the net present value of the benefits in aggregate over the project's lifetime. While hourly avoided energy generation, carbon, and health costs can be multiplied by estimates of hourly energy generation savings, it is time-intensive to apply the avoided energy generation costs in this way and can lead to a false sense of precision. Synapse aggregates these avoided costs to summer peak, summer off peak, winter peak, and winter peak periods as defined by PJM.

[54] U.S. EPA. 2020. *Estimating Particulate Matter Emissions for eGRID*. Available at https://www.epa.gov/sites/default/files/2020-07/documents/draft_egrid_pm_white_paper_7-20-20.pdf.

Appendix C: Macroeconomic Impact Modeling Methodology

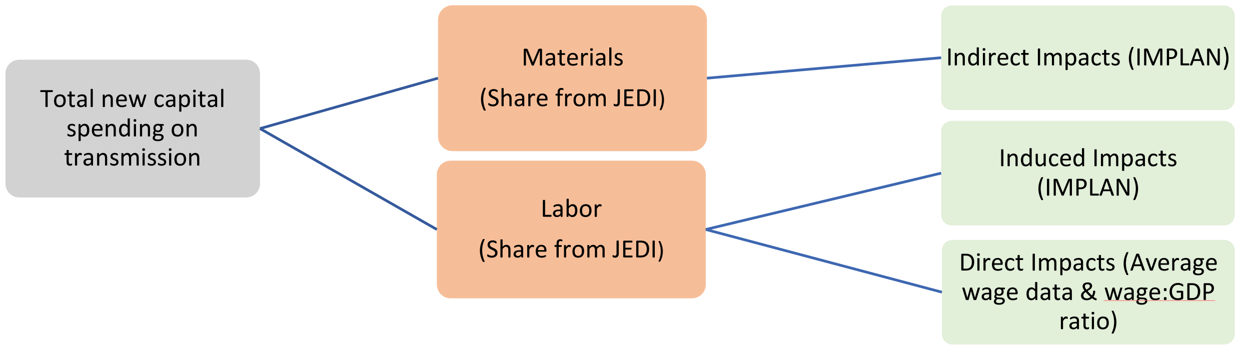
A Composite Modeling Approach: IMPLAN and Other Methods

Synapse employs a composite approach to model macroeconomic impacts that utilizes the IMPLAN model in conjunction with other complementary methods.[55] The IMPLAN model is generally used to estimate indirect, supply chain impacts, along with induced effects. Meanwhile, Synapse usually projects direct impacts outside of IMPLAN. Though IMPLAN's detailed model of the economy permits precise and reliable modeling of supply chain and induced effects, the modeling resolution of IMPLAN (and specifically, its economic sectorization) does not support accurate modeling of many construction or O&M activities in the electric sector. Though IMPLAN's sectorization includes relevant electric sector industries and commodities, these industries and commodities are often too aggregated to accurately capture the specific effects associated with changes in spending on particular resources, including incremental spending on wind and transmission.

The following is a more detailed description of the composite modeling approach Synapse uses to estimate economic impacts associated with changes in spending on grid resources. For illustrative purposes, this analytical process reflects a hypothetical investment in transmission infrastructure. The composite economic impact analysis methodology appears in a schematic on the following page.

1. A labor-materials split factor based upon data from NREL's JEDI model[56] defines the "direct" share of total capital spending for the transmission project – i.e., the portion of total project spending on direct labor (equivalent to the direct income effect).
   The average wage for those employed in the direct roles determines the employment impact associated with the direct income effect and is used to calculate the total number of jobs created by dividing the total direct labor income by this average wage.
   A ratio of GDP-to-income for the transmission sector based upon Delaware state economic data (from IMPLAN) determines the direct GDP impact.
2. The total materials spending value is distributed across a range of implicated industries or commodities (accounting for in-state industrial concentration/leakages out of state).
3. IMPLAN's default macroeconomic factors are used to determine the induced impact of workers re-spending wages (labor share)

Figure 8: Schematic of Synapse's composite approach to economic impact analysis



For this analysis, Synapse uses a composite approach to model the impacts of new capital spending on offshore wind and transmission facilities.

[55] IMPLAN is an industry standard input-output model. See www.implan.com for more detail.
[56] National Renewable Energy Laboratory (NREL). Accessed October 5, 2020. "JEDI: Jobs & Economic Development Impact Models." Available at: https://www.nrel.gov/analysis/jedi/models.html.

Synapse utilizes IMPLAN alone to model the induced impacts associated with the forecast change in aggregate utility rates and bills. This analysis is conducted in IMPLAN using IMPLAN's default spending patterns for households and businesses which predict how increases or reductions in spending will affect the myriad industries that make up the state economy.

Synapse also uses only IMPLAN to assess the effects of the reduction in gas generation O&M at Delaware facilities that would be expected to occur as a result of a new PPA to supply Delaware electric customers with wind energy from the envisioned offshore facility was modeled exclusively within in IMPLAN.

Key Parameters and Assumptions

For this analysis, Synapse utilizes IMPLAN's Delaware state dataset for 2018. Since there is a one-year lag in IMPLAN data, the data utilized for this analysis is approximately 4 years old. In Synapse's view, these data, though not the most current available, aresuitable for this analysis in consideration of the following:

- Changes to the structure of the Delaware state economy that have occurred over the period 2018-2022 are likely to have been quite modest.
- Estimated construction direct impacts –associated with the modeled expenditures on offshore wind and transmission– were determined outside of the IMPLAN model and thus are not sensitive to IMPLAN dataset vintage; for transmission construction, direct job impacts and direct income impacts represent the large majority of total jobs and total income impacts.
- Impacts associated with changes in spending on gas generation are very small relative to total impacts.
- Impacts associated with changes in electric utility bills are the largest contributor to overall impacts. Since these impacts reflect spending in the entire economy and implicate all economic sectors, the associated multipliers (jobs-per-million-dollars, etc.) are not likely to have significantly changed since 2018.

Developing Spending Models for IMPLAN for Offshore Wind and Transmission

Synapse utilizes customized spending models to model many types of electric grid spending in IMPLAN. These spending models direct IMPLAN on how to distribute spending changes to the various affected industries or commodities. Synapse develops these spending models, or "resource vectors," largely based upon NREL's JEDI models. In turn, Synapse typically permits IMPLAN to apply stock assumptions about the supply chains of each the industries or commodities included on the resource vector for a given grid resource, including, notably, the share of demand for each of the included industries or commodities that is met by in-state firms. The share of demand met by Delaware-based businesses is indicated with the Regional Purchase Coefficient (RPC).

For this analysis, Synapse uses custom-developed resource vectors to model expenditures on offshore wind construction and onshore transmission construction. Reduced spending on gas generation was modeled using a single IMPLAN industry (described in more below), while changes in economywide spending stemming for increases or decreases in utility bills were modeled using IMPLAN's default institutional spending patterns (also described in more below).

The following tables present Synapse's spending models for construction of offshore wind facilities and construction of transmission facilities.

Table 8: Offshore wind construction spending model for IMPLAN (indirect impacts)

Sector Name	Share of Spending	Regional Purchase Coefficient
Turbine and turbine generator set units	47.2%	0.01%
Prefabricated metal buildings and components	7.7%	0.04%
Iron and steel forgings	14.0%	0.05%
Cut stone and stone products	0.1%	4.12%
Electricity transmission and distribution	10.1%	23.33%
Architectural, engineering, and related services	15.8%	17.87%
Warehousing and storage services	2.0%	23.72%
Other financial investment services	2.1%	23.55%
Marketing research and all other miscellaneous professional, scientific, and technical services	0.5%	19.41%
Insurance agencies, brokerages, and related services	0.5%	25.00%

Table 9: Onshore transmission construction spending model for IMPLAN (indirect impacts)

Sector Name	Share of Spending	Regional Purchase Coefficient
Wiring devices	21.0%	0.48%
Architectural, engineering, and related services	13.7%	71.46%
Aluminum sheets, plates, and foils	11.7%	0.01%
Fabricated structural metal products	11.3%	5.81%
Power, distribution, and specialty transformers	8.4%	0.01%
Aluminum sheets, plates, and foils	8.3%	0.01%
Plates	6.9%	4.22%
Other real estate services	6.9%	98.53%
Rolled, drawn, and extruded aluminum	4.3%	0.06%
Prefabricated metal buildings and components	3.6%	0.16%

As noted above, the regional purchase coefficient indicates the share of demand present in Delaware for a given good or service that is met by Delaware firms. For manufactured component, the regional purchase coefficients are quite low, since there is little relevant manufacturing supply chain activity in Delaware. Meanwhile, the share of relevant service demand that is met by Delaware firms is relatively high.

Synapse uses the IMPLAN's default regional purchase coefficients to model onshore transmission indirect effects in IMPLAN. For offshore wind construction modeling, Synapse scaled down the default regional purchase coefficients by 75 percent (i.e., multiplying the coefficients by 0.25) to reflect the expectation that the majority of offshore wind facility materials (goods and services) demand would arise in states other than Delaware.

Direct Effect Modeling Parameters for Offshore Wind and Transmission

The direct effects associated with new spending on offshore wind and onshore transmission facilities were modeled outside of IMPLAN, consistent with the approach described earlier in this Appendix. The parameters for this direct effect modeling are presented below in the table below.

Table 10: Direct effect modeling parameters

Resource	Direct Labor Percentage[57]	Proportion of Direct Labor from Delaware[58]	Average Direct Labor Wage[59]	GDP-to-Wage Ratio[60]
Offshore Wind Construction	6%	25%	$91,029	2.34
Onshore Transmission Construction	26%	100%	$51,767	0.00

Approach to Modeling Reduced Gas Generation O&M Spending

Synapse uses IMPLAN alone to estimate the economic impacts of the reduction in gas generation O&M at Delaware facilities that would be expected to occur as a result of a new PPA to supply Delaware electric customers with wind energy from the envisioned offshore facility. Synapse utilizes the "Electric Power Generation – Fossil fuel" industry for this modeling.

To estimate the share of total reduction in gas generation expected to occur at Delaware facilities (versus facilities in other PJM states), Synapse used EPA's Avoided Emissions and Generation (AVERT) model.[61]

Approach to Modeling Induced Impacts of Utility Rate and Bill Changes

Synapse utilizes IMPLAN alone to model the induced impacts associated with the forecast change in aggregate utility rates and bills. This analysis is conducted in IMPLAN using IMPLAN's default spending patterns for households and businesses which predict how increases or reductions in spending will affect the myriad industries that make up the state economy.

[57] The direct labor percentage indicates the share of spending for the given resource that goes to direct labor income. These values are sources from NREL's JEDI models.

[58] For offshore wind construction, the same 25-percent coefficient is applied for direct labor as is used to scale down the default IMPLAN regional purchase coefficients. For transmission construction, it is assumed that all direct laborers are Delaware residents.

[59] The average direct labor wage indicates the average earnings, on a per-year basis, of those employed in direct labor for the given resource. These values are sourced from the NREL's JEDI model and the U.S. Energy and Employment Jobs Report (USEER).

[60] The GDP-to-Wage ratio is a scalar that we use to impute the total GDP impact associated with the direct labor spending. These values are calculated using IMPLAN's state economic data. For conservatism, we assume no GDP contribution from construction of transmission.

[61] See: https://www.epa.gov/avert.