The Development and Economic Viability of Offshore Wind in the US: Assessing Current Challenges and Charting Policy Solutions

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ABSTRACT

Offshore wind (OSW) is becoming a critical energy solution for the US, offering a sustainable solution to meeting growing energy demands while addressing decarbonization targets. In 2021, the Biden administration set an ambitious target of reaching 30 GW of OSW energy by 2030. However, progress toward this goal has been sluggish, with various challenges hindering deployment. The lingering impacts of the COVID-19 pandemic and the resulting macroeconomic shifts have further complicated deployment efforts. Given the recent nature of these events, existing literature has not comprehensively identified the underlying factors behind slow OSW development. Against this backdrop, this study combines case studies and secondary data analysis to examine the difficulties faced by OSW projects from January 2021 to December 2023 due to macroeconomic uncertainty, complex permitting processes, and supply chain disruptions. Furthermore, I conducted interviews with industry experts to investigate potential policy solutions to address domestic infrastructure, financing, permitting, transmission, and community benefits concerns. Findings show multi-year delays for OSW projects and lengthened timelines for near-term development. My results also indicate the main recent barriers to US OSW development are unfavorable macroeconomic and geopolitical environment, lack of adequate infrastructure for construction and operations, and aggressive seabed lease bidding behavior. The findings of this study aim to inform policymakers and relevant stakeholders about both the opportunities and challenges within the OSW sector, focusing on adaptive strategies that can advance future development amidst ongoing economic headwinds.

KEYWORDS

COVID-19 pandemic, energy transition, stakeholder engagement, project financing, policy

INTRODUCTION

The offshore wind (OSW) industry is rapidly growing in the US and playing an increasingly pivotal role in the country's sustainability and clean energy goals. Although wind power currently contributes only 7.1% of the nation's energy output, OSW holds immense technical resource potential. With a domestic potential capacity exceeding 2,000 GW, or 7,200 TWh of annual generation – nearly double the country's electricity needs, as of 2016 – the promise of OSW energy is evident (Powers et al. 2022, Hartman 2016). In 2021, the Biden Administration set a national OSW energy target of 30 GW by 2030, a target that has been complemented by various states establishing their own OSW goals (Shields et al. 2023). As the US moves to achieve net-zero emissions, OSW emerges not merely as a promising but as an essential component of the nation's energy portfolio. Compared to onshore wind, OSW can generate higher energy production, owing to larger wind turbine ratings and proximity to stronger wind profiles, resulting in a 150% increase in electricity production (Perveen et al. 2014; Snyder and Kaiser 2009). Additionally, in contrast to traditional energy sources such as natural gas and coal, OSW exhibits significantly lower carbon emissions over its lifecycle and minimal nitrous oxide and sulfur oxide emissions (Snyder and Kaiser 2009). Beyond its environmental benefits, OSW stands to create tens of thousands of jobs, foster sustainable development, enhance energy security, and contribute to a diversified energy profile (Dinh and McKeogh 2018, McDermott-Murphy 2022).

Despite the considerable potential of the OSW industry, developers confront many challenges throughout the development process (Perveen et al. 2014). The planning, permitting, and construction of OSW projects are technically and operationally complex and require upfront, large-scale investments. Moreover, regulatory and legal barriers can lead to prolonged permitting processes and costly site assessments (Van Cleve and Copping 2010). Notably, the average cost of OSW stands at 22.15 cents/kWh while onshore wind is 8.66 cents/kWh (Institute for Energy Research 2013). The cost of electricity generated by a farm is dependent on economic depreciation, operation and maintenance (O&M) costs, and taxes (Perveen et al. 2014). Policy uncertainties, at the state and federal levels, as well as the COVID-19 pandemic further complicate the landscape for development, making OSW more expensive. To ensure future revenue streams and financing needed to justify the hefty capital expenditures, most, if not all, developers enter into power purchase agreements (PPAs) – a contractual agreement between the developer and entities to purchase the electricity generated at a specified price and volume (Bruck et al. 2018). PPAs function as offtake contracts, defining the conditions of buying and selling energy before production commences.

Entering 2022, several projects in the US started facing economic headwinds, supply chain disruptions, and regulatory challenges (US Department of Energy 2023). Global supply chain bottlenecks and unfavorable macroeconomic conditions, exacerbated by geopolitical tensions, have greatly affected projects' production timelines and financial costs. Many developers, citing rising costs, have asserted the financial non-viability of their projects, leading to requests for PPA renegotiations of existing agreements (Fargo 2022). Recently, provisions in the Inflation Reduction Act (IRA) have aimed to incentivize OSW development and alleviate developers' financial burdens, providing up to 30% in tax credits for offshore wind projects beginning construction before 2026 (US Department of Energy 2022). Nevertheless, it is uncertain whether these initiatives will sufficiently place OSW development back on track to meet 2030 OSW goals.

The COVID-19 pandemic and subsequent shifts in the macroeconomic landscape have posed unprecedented challenges for developers and their projects. Yet, these challenges remain relatively underexplored in research due to their recent emergence. With the US lagging in OSW development compared to other international markets, it is crucial to assess the changes in market dynamics to help formulate adaptive strategies for the industry's future success. This study evaluates the current state of OSW projects in the US, recent challenges faced by developers, and policy gaps hindering the attainment of 2030 OSW targets. Against this backdrop, this paper's central research question is how should the US OSW industry adapt to ongoing economic headwinds and development shortcomings? Specifically, I ask the following subquestions:

1. What is the current market outlook for existing OSW projects in the US?
2. What factors are contributing to the development challenges and financial distress in the US OSW market?
3. What policy solutions exist to support current and future US OSW development?

To identify relevant and effective policy solutions to advance OSW development, this study employs case studies, literature reviews, and discourse analysis. Secondary data has been gathered to understand the impacts of COVID-19 and the macroeconomic environment on OSW construction, as well as to uncover the causes of short- and long-term development challenges. All in all, this study aims to pinpoint critical policy solutions to revamp and accelerate OSW growth.

BACKGROUND OF US OFFSHORE WIND

To identify potential improvements in policy solutions for OSW development, it is important to first understand 1) the policy landscape, 2) the state of OSW progress in the US, 3) the process of stakeholder engagement and tribal resources, and 4) existing academic literature on the industry. The federal government and state agencies share responsibility and jurisdiction over different phases of OSW development. Through the Bureau of Ocean Energy Management (BOEM) and the US Department of Energy, the federal government manages the leasing process and conducts environmental reviews. On the other hand, states hold authority over their renewable energy targets and standards, procurement and offtake agreements (which include either power purchase agreements (PPAs) or offshore wind renewable energy certificates (ORECs) depending on the state), and coastal zone management. Further, states are individually responsible for onshore infrastructure permitting and economic development.

Critical US Offshore Wind Policies

The US OSW industry has been driven by technology advancements, federal and state incentives, and policies. Regulatory frameworks substantially impact project feasibility, financing, permitting, and overall development. Among the several legislative actions and federal statutes that have shaped the industry, seven measures stand out. They are outlined below.

Sections 45 and 48 of the Internal Revenue Code: Production Tax Credit and Investment Tax Credit (1962)

Under Section 45 of the Internal Revenue Code (IRC), the Production Tax Credit (PTC) allows developers to claim a federal income tax credit on every kilowatt hour (kWh) of electricity produced at an OSW farm (US Department of Energy 2024). The tax credit is applicable for a specified period, which is often ten years (US Department of Energy 2024). On the other hand, the Investment Tax Credit (ITC) as outlined in Section 48 of the IRC, is a one-time federal income tax credit based on the dollar amount of a capital investment into an OSW project (US Department of

Energy 2024). In 2025, tax credits for OSW will be replaced with technology-neutral credits (Cofer et al. 2023).

Inflation Reduction Act (2022)

The Inflation Reduction Act (IRA) encourages large-scale clean energy investment by extending the PTC and ITC through 2024 for energy projects that begin construction before January 1, 2025 (US Department of the Treasury 2023). The full investment tax credit is 40%, with a 10% domestic content bonus available for projects that meet "domestic content thresholds" or ensure high-quality job creation (US Department of the Treasury 2023). However, for developers to be eligible for the full ITC or PTCs, projects must meet certain prevailing wage and apprenticeship requirements or be under construction within 60 days after the guidance from the Treasury secretary is issued (Kiely 2022).

Additionally, the IRA includes new and revised tax incentives for projects with PTC, providing an extension from the original Sections 45 and 48 of the Internal Revenue Code (Sections 45 and 48 of the Internal Revenue Code). Moreover, the law has authorized $700M to implement the National Environmental Policy Act (NEPA) to increase staffing (for reviewing and approving applications, conducting environmental assessments, etc.) and reduce delays in developing OSW projects (Mirza and Williams 2022). These provisions have spurred financial incentives for greater OSW investments and alleviated some developer burdens.

Initial guidance for the energy community bonus was released by the US Department of the Treasury in April 2023 (US Department of the Treasury 2023). This bonus would allow developers to secure an additional tax credit (up to 10% for ITC and an increase for PTC) for projects located in fossil fuel communities (US Department of the Treasury 2023). Further guidance on which areas qualify as "energy communities" was published in March 2024 (US Department of the Treasury 2024).

Jones Act (1920)

Designated to protect US maritime capacity, the Jones Act (also known as "Merchant Marine Act of 1920") has meaningful implications for OSW development in the United States. The Jones Act mandates that all goods transported by water between two points in the US must be carried on US-built, owned, crewed, and flagged vessels (US Customs and Border Protection

2024). Therefore, the transportation of any equipment, components, and labor to and from OSW sites must comply with the Jones Act. This act has important repercussions for developer costs and transportation logistics, and further analysis of this will be conducted throughout this paper.

Outer Continental Shelf Lands Act (1953)

The Outer Continental Shelf Lands Act (OCSLA) governs the federal government's role in leasing and managing offshore lands and resources. Specifically, OSCLA grants the Secretary of the Interior, through BOEM, the authority and regulatory responsibility associated with leasing out offshore wind areas for energy development (Bureau of Ocean Management 2024). Per the Act, BOEM is required to conduct environmental assessments in compliance with the National Environmental Policy Act (NEPA) of 1970 (Bureau of Ocean Management 2024).

Coastal Zone Management Act (1972)

The Coastal Zone Management Act (CZMA) provides a framework for states to manage their coastal zones, combining resource protection with the management of economic, recreational, and cultural needs (Kaiser 2021). Although the focus of the CZMA is preserving and monitoring the coastal environment, it includes provisions that guide the permitting and siting, environmental protection, and community engagement processes in OSW development. Pursuant to the CZMA, the "federal consistency" provision mandates that federal activities (including OSW development) that directly affect a state's coastal uses or resources must be consistent with the state's coastal management plan (Smith and Dicharry 2021, National Oceanic and Atmospheric Administration 2024).

Overview of US Offshore Wind Development & Leasing

There are several OSW projects in various stages of development in the US, predominantly along the East Coast. Whilst there is an unprecedented level of interest and policy support in the industry, developers are consistently facing distressing financial conditions that are threatening the viability of most near-term projects. As of August 2023, only two domestic farms were in operation: Block Island Wind and Coastal Virginia Offshore Wind Pilot Project (US Department of Energy 2023). In January 2024, two additional projects, South Fork and Vineyard Wind 1, began delivering power to New York and Massachusetts respectively (DiSavino and Buli 2023, Vineyard Wind 2024). To date, eight projects have been approved by the federal government for the East Coast with more in the permitting and reviewing process (US Department of the Interior 2024). On the West Coast, BOEM leased 370,000 acres over five areas in 2022, and the first commercial-scale farm is expected to be built around 2030 (US Department of the Interior 2022a, Laurie 2023). The Gulf of Mexico saw its first auction of leases for OSW projects in August 2023, with BOEM leasing areas off the coast of Louisiana and Texas (Friedman 2023). BOEM applies a four-phase process between leasing to operations: 1) pre-survey meetings and planning, 2) site assessment and surveys, 3) BOEM environmental and technical reviews, and 4) installation (Bureau of Ocean Energy Management 2020). The length of this process varies widely for each project, and it can take up to eight years before the final construction and operations plan (COP) is approved (Bureau of Ocean Energy Management 2020).

Stakeholder & Tribal Engagement in US Offshore Wind

Developers and regulatory agencies have engaged in public outreach efforts; however, many stakeholders continue to voice their frustrations regarding procedural unfairness and the lack of meaningful discourse during project planning (Dwyer and Bidwell 2019). Insufficient engagement with stakeholders can precipitate local opposition, posing an obstacle to the development and viability of projects (Mirza et al. 2023).

Purposeful and productive stakeholder engagement requires several key elements; the main ones include 1) collaborative dialogue with interest groups, host communities, developers, government agencies, and environmental organizations, 2) development of shared priorities among stakeholders, and 3) clear identification of needs and challenges faced by participating groups and local stakeholders (Brunbauer et al. 2023).

States have varying approaches and commitments to stakeholder engagement, as do different BOEM regional offices. In New York and New Jersey, the Offshore Wind Environmental Justice Forum (EJF) was created by BOEM to increase engagement between community organizations and state and federal agencies (Bureau of Ocean Management 2024). Members of the EJF meet quarterly to discuss environmental justice issues relevant to the New York Bight Programmatic Environmental Impact Statement (PEIS) (Bureau of Ocean Management 2023). The

PEIS reports potential environmental and social impacts resulting from project leases and analyzes mitigation and monitoring strategies that can be applied (Bureau of Ocean Management 2023). Additionally, in New York, two technical working groups were developed in 2017 to identify the needs for fisheries and environmental resources and inform responsible OSW development regionally (Brunbauer et al. 2023). The technical working groups are composed of project developers, non-governmental organizations, as well as federal and state agency representatives. However, non-indigenous and tribal communities were not directly included in these working groups (Brunbauer et al. 2023). The establishment of technical working groups represents a step forward in addressing environmental and social considerations, but the absence of indigenous and tribal stakeholder representation highlights the need to address broader inclusivity and environmental equity issues.

Academic Literature

Academic literature, published before and after COVID-19, highlights three primary challenges facing OSW development and financing in the US: 1) protracted and complex permitting processes, 2) high upfront capital costs and uncertainty for return on investment, and 3) insufficient policy stability and incentives.

Protracted and complex permitting processes

Scholars such as DeCastro et al. have noted that developers are required to participate in environmental and site assessments set by federal government regulations in addition to obtaining permits issued by different agencies at the state and local levels (DeCastro et al. 2019). The challenges intensify due to jurisdictional overlaps and inadequate coordination among these agencies, which can lead to contradictory decisions and delays in development (DeCastro et al. 2019).

High upfront capital costs and uncertainty for return on investment

Other scholars have identified another hurdle in OSW development as early years financing, notably the high cost of projects in the development phase. The largest share of costs for a project comes from the upfront capital expenditures, necessitating financing ahead of revenue generation (Hansen et al. 2024). Given the status of the economy – which in 2021 - 2023 was characterized by inflation and higher interest rates – securing financing for high capital expenditures has become more difficult, yet it remains a critical component for developers to keep costs minimal (Hansen et al. 2024). Without assurance of stable revenue streams, investors are hesitant to agree to low financing costs years before the completion of a project.

Insufficient policy stability and incentives

Existing studies have noted that the US operates OSW with a less standardized approach than some countries, such as Germany (Portman et al. 2009). There are no federal mandates on energy mix and renewable energy production, and developers receive less support and funding for developing OSW farms in some states (Portman et al. 2009). To foster greater OSW development in the US, there is a need for more uniform support mechanisms and larger incentives to offset the financial and logistical burdens developers face.

In the limited academic literature available on the development and economics of OSW projects post-COVID, particularly from 2021 onwards, select studies have delved into the repercussions of the pandemic on project productivity, with a focus on its effects on the Chinese markets. Lerche et al. (2022) revealed that disruptions caused by COVID-19 harmed project productivity, leading to significant delays and an interesting finding that waiting constitutes 50.09% of the dominant activity in projects. The study noted that delays were primarily caused by bottlenecks in both materials and resources. Consequently, the authors emphasized the need for establishing a robust management and control system to monitor delay factors. Likewise, Jamali et al.'s 2021 study concluded that COVID-19 either slowed down or completely halted the development of OSW projects, resulting in increased construction costs. However, the study also noted a subsequent decrease in the cost of OSW energy generation.

The adverse effects of the pandemic extended beyond the OSW industry. In 2020, solar panel and grid installations saw a decline, and onshore wind construction faced severe disruptions in Spain (Bashir et al. 2022). In response, various governments have implemented policy measures to promote renewable energy development and assist businesses in overcoming the economic consequences of COVID-19; examples include the IRA in the US and the REPowerEU plan in the European Union. The "green economic recovery" concept is gaining prominence in literature, whereby economic development strategies are aligned with long-term climate change and sustainability objectives (Taghizadeh-Hesary 2023). Within green economic recovery, fiscal policy emerges as a crucial factor in environmental preservation and support for green-specific priorities, including OSW development (Taghizadeh-Hesary 2023). Redirecting investments away from natural gas and oil energy toward greener alternatives presents an opportunity for the US to foster renewable energy growth, support workforce development, and boost the broader economy. Moreover, existing literature advocates for policymakers to integrate adaptive energy policies with a long-term perspective, enact policies that mitigate risks posed by economic shocks such as COVID-19, offer automatic relief for those most affected by crises (e.g., cheaper consumer energy prices), and utilize hybrid instruments with environmental integrity mechanisms (Bashir et al. 2022).

METHODS

Case Studies & Market Outlook

Given the concentration of projects in East Coast states and their relative maturity compared to those along the West Coast and Gulf of Mexico (which are still in the preliminary planning and permitting stages), this study will center its investigation on the status and market outlook of East Coast projects. Specifically, I will examine six projects and different developers. Each of these selected projects involves at least one developer operating as a public company. Selecting projects developed by publicly listed companies improves the accessibility and comprehensiveness of the research process given these companies are mandated by federal regulations to disclose all relevant financial information to prospective investors and shareholders (Stanford Law 2024). The analysis that follows spans January 2021 to December 2023. Further, the selected projects are situated in the following states: New York, New Jersey, Massachusetts, and Rhode Island. By analyzing six case studies, the primary objective of this research framework is to offer insights into the real challenges developers are facing amid the backdrop of macroeconomic uncertainty. Consequently, these findings aim to inform practical strategies that can be implemented to effectively navigate and overcome these challenges. The six projects are outlined below.

Revolution Wind – a proposed 704 MW project located on the coast of Rhode Island. It is a 50-50 joint venture between Ørsted and Eversource (Revolution Wind 2023). The project has been awarded three PPAs: a 200 MW contract with the State of Connecticut, a 400 MW contract with the State of Rhode Island, and another 104 MW contract with the State of Connecticut (Musial et al. 2023).

New England Wind – a proposed 2,032 MW project to be developed in 2 phases, known as Park City Wind (phase 1) and Commonwealth Wind (phase 2) (Rhode Island Coastal Resources Management Council 2023). Avangrid, a subsidiary of the Spanish utility company, heads the project in sole ownership. The project has secured two PPAs with the National Grid, Eversource Energy, and United Illuminating (UI) (Musial et al. 2023).

SouthCoast Wind – a proposed 2,036 MW project located in Massachusetts, south of Martha's Vineyard, as a joint venture between Shell, EDP Renewables, and Engie (EDP Renewables and Engie form Ocean Winds North America) (SouthCoast Wind 2024). The project was renamed from Mayflower Wind in early 2023 and has secured PPAs with the Massachusetts electric distribution companies (Musial et al. 2023).

Empire Wind 1 – an 816 MW 50-50 joint venture between Equinor and BP (New York State Energy Research and Development Authority 2024). The project won a 25-year contract of renewable energy credits, in the form of ORECs, from the New York State Energy Research and Development Authority (New York State Energy Research and Development Authority 2024).

Beacon Wind 1 – a 1,230 MW 50-50 joint venture between Equinor and BP (Beacon Wind 2024). The project won a 25-year contract of renewable energy credits, in the form of ORECs, from the New York State Energy Research and Development Authority (Bureau of Ocean Management 2024).

Ocean Wind 1 and 2 – Ocean Wind 1 (1,100 MW) and Ocean Wind 2 (1,148) are projects, developed by the Danish energy group, Ørsted, located in New Jersey (Ørsted 2023). Ocean Wind has secured a 20-year OREC with various utilities in New Jersey (Power Technology 2023). In 2021, the New Jersey Board of Public Utilities (BPU) awarded a 20-year OREC to Ocean Wind 2 (Ørsted 2021).

Periodically, I tracked the status and developments of these projects using press releases published by developers and state news articles (e.g., the *Connecticut Examiner* and *New York Times*). Filings from developers to the state public utility commission, along with the commission's response(s), were used to monitor the terms of PPA negotiations, reasons for project termination, and general comments.

Literature Research & Analysis

To determine the current outlook of the US OSW market and analyze the factors contributing to financial distress and development challenges for projects, I focused my literature research, in order of priority, on four types of sources:

1) Official reports from government agencies – e.g., the US Department of Energy, US Department of the Interior, National Renewable Energy Laboratory, Bureau of Ocean Energy Management, and each state's Department of Public Utilities
2) Research from academic literature and industry think tanks – e.g., World Resources Institute, American Clean Power Association, Cato Institute, and The Brattle Group
3) Public information released by developers – e.g., Capital Market Day reports, annual financial reports, quarterly earnings call transcripts, and press releases
4) State or renewable-energy-related newspaper and media outlets – e.g., BloombergNEF, Reuters, Recharge News, and S&P Global

In sequential order, official reports provided valuable insights into the status of OSW projects as well as the pipeline of future development, overarching challenges facing the industry, and recent policy initiatives. Academic literature and publications from industry think tanks offered in-depth analyses of market dynamics, weaknesses in regulatory frameworks, and policy opportunities. Public information released by developers allowed for a closer examination of strategic decisions, project milestones, and financing structures. Specifically, quotes from C-suite developer executives during earnings calls pinpointed the evolving challenges of financing, constructing, and maintaining projects. Given the volatility of projects, news and media platforms were used to provide real-time updates on industry events and stakeholder perspectives. Upon aggregating data, I cross-referenced all information and analyzed key trends regarding project development, financial performance, and regulatory compliance.

Adopting various sources was important to showcase the differing perspectives of stakeholders (i.e. developers, state and federal governments, and industry leaders) on the current outlook and key challenges facing the industry – providing a more holistic interpretation of OSW economic viability and development. In cases where the literature provided policy recommendations, which were commonly found in reports published by think tanks, these were considered and incorporated to complement primary research findings from interviews with industry experts.

Policy Interviews with Industry Experts

To identify policy priorities and potential solutions for accelerating US OSW development, semi-structured interviews were conducted with four industry experts from the Natural Resources Defense Council (NRDC), the Brattle Group, and the American Clean Power Association. Each interviewee specialized in distinct areas of US OSW policy, ranging from geographical regions to subfields within OSW development (e.g., transmission, infrastructure, permitting, etc.). All interviewees were asked to address the following aspects:

1. Topical issues facing the US OSW industry
2. Short-term and long-term priorities for development
3. Policy solutions to encourage and support projects
4. Hurdles for policy solutions implementations
5. Ranking of importance for proposed policy opportunities

Given the diverse expertise of the interviewees, I asked subsequent follow-up questions to dive deeper into the specifics of their respective subfields. For example, transmission experts were asked about issues such as disjoined leases and procurement processes, and specialists in domestic infrastructure were questioned about the impact of the Jones Act on project construction and contracting backlogs. This tailored approach enabled a more comprehensive understanding of each key aspect of OSW development outlined above.

RESULTS

Current Outlook of the US Offshore Wind Market

Despite having a significant coastline and ample wind resource availability, the US trails behind China, the UK, and Germany in terms of cumulative installed capacity (Powers et al. 2022).

Presently, the US OSW industry has achieved an online capacity of 42MW with an additional 51,377 MW in the development pipeline (American Clean Power 2023). Disruptions throughout 2021 and lasting until 2022 led to only two projects under construction in federal waters the year after – 1) Vineyard Wind 1 (816MW) by Avangrid and Copenhagen Infrastructure Partners and 2) South Fork Wind Farm (132MW) by Ørsted and Eversource (American Clean Power 2023). Indications of headwinds in the OSW industry have been looming for an extended period, but financial and operational struggles have only become more apparent in recent years. Numerous projects, notably those with an expected commercial operation date (COD) between 2024 and 2028, are now underwater, unable to overcome high capital costs and receive reasonable returns at the same time (Musial et al. 2023). As a result, developers have either attempted PPA renegotiations, halted/pushed back projects, or in the most extreme cases, terminated projects in hopes of rebidding and securing higher PPA prices in upcoming procurements (Musial et al. 2023).

Key Finding 1: Most, if not all, OSW projects are experiencing sizable delays in their CODs.

Financial difficulties, supply chain issues, and the COVID-19 pandemic have caused major delays in projects along the East Coast. Developers are grappling with higher interest rates and struggling to garner enough tax credits, prompting some to delay project schedules in anticipation of a more conducive economic climate for construction activities (Østed 2023, Crowley 2023). During the third-quarter earnings call of 2023, Mads Nipper, President and CEO of Ørsted, underscored the detrimental impacts of supply chain challenges and permitting issues on project schedules and the construction of OSW farms (Ørsted 2023). In response, Ørsted has initiated a new installation approach with extended timelines for projects Revolution Wind and Sunrise Wind (Ørsted 2023).

Adding to the complexity, the scarcity of installation vessels in the market is resulting in multi-year setbacks for numerous projects. Further, the rapid revolution of OSW turbine sizes has outpaced the expansion of both the quantity and capacity of installation vessels equipped to handle them (Stone and Collopy 2023). As a result, developers are facing intense competition to secure access to a limited pool of vessels. The scarcity of installation vessels also presents a significant risk during the construction phase, when delay on one commercial-scale OSW project may impose delays on the next in a domino effect.

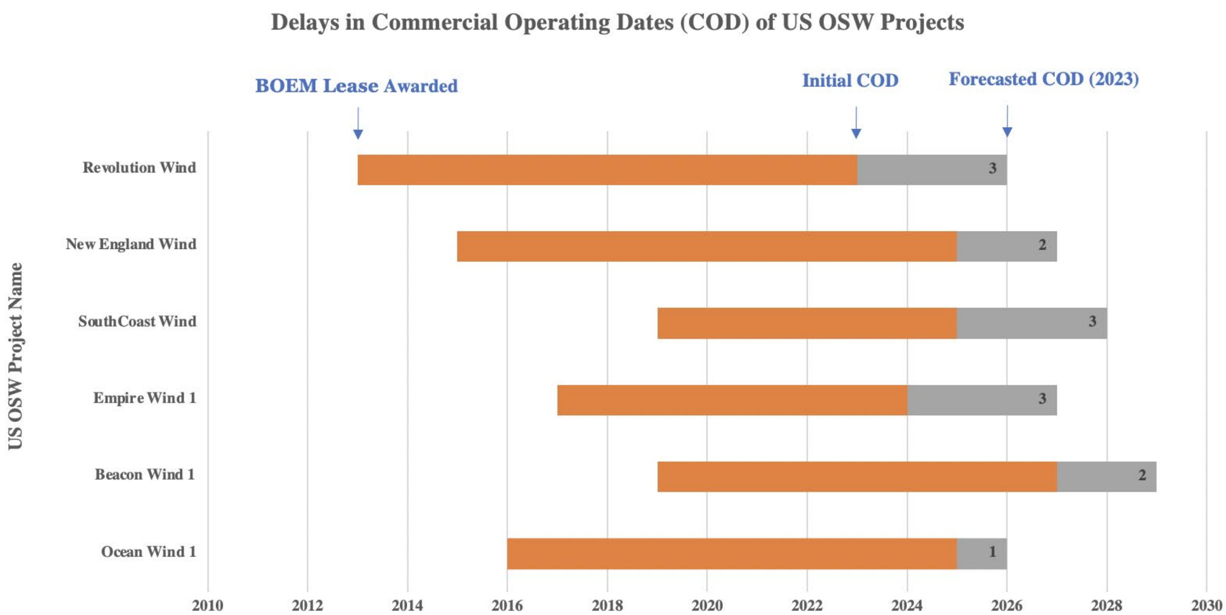

Figure 1. 2023 Delays in Commercial Operation Dates of US OSW Projects.

Across the six case studies of OSW projects, the average delay in COD was 2.3 years (Figure 1). Revolution Wind was previously scheduled to be commercially operating by 2023, yet the approval of the project's COP was only received in August 2023 (Bureau of Ocean Energy Management 2023). Outside these case studies, many other projects have seen multi-year setbacks in CODs (Musial et al. 2023). For most projects, announcements of COD delays have coincided with the filing of motions to the relevant state Public Utilities Commission to review their existing PPA. Notably, in October 2022, Avangrid established new dates for commercial operation for New England Wind (Park City Wind and Commonwealth Wind in 2027 and 2028 respectively) when it requested the Massachusetts Department of Public Utilities (DPU) to suspend the review of the PPA for a month. Ultimately, the project was canceled entirely in 2023 with Avangrid agreeing to pay a $16M fine (Buljan 2022, Wade 2023).

Key Finding 2: As current PPA agreements are not adjusted for inflation, and developers find insufficient financial support to alleviate burdens, project cancellations are becoming more common.

Developers face higher OSW energy costs given supply chain constraints, in addition to higher inflation affecting commodities, services, and labor costs. These factors have contributed to significant reported hikes in levelized cost of energy (LCOE) for OSW. LCOE, representing the average net present cost of electricity generation for a generator over its lifetime, serves as the principal benchmark for PPA prices (Ryor and Tawney 2015). For a project to be financially feasible, the levelized nominal PPA price must exceed the nominal LCOE – the difference between the two is determined by a developer's specified internal rate of return (IRR) (Miller et al. 2017).

$$Levelized\ Cost\ of\ Energy\ (LCOE) = \frac{Projected\ Total\ System\ and\ Operating\ Costs}{Total\ MWh\ Produced\ over\ the\ Lifetime\ of\ Project}$$

However, the LCOE of a subsidized US OSW project has surged by almost 50% over the past two years, from \$77.3/MWh in 2021 to \$114.2/MWh in 2023 (Jain 2023). Despite cost increases, developers have been unable to secure higher revenues through renegotiating PPA prices, given the nature of their contracts. Most PPAs for US OSW projects do not include mechanisms for adjusting to higher interest rates, costs, or any extraneous circumstances. Furthermore, the 30% ITC benefit, in proportion to total capital expenditure, has minimal impact on offsetting the higher costs. Without the promise of financial returns, the large capital investment required for OSW projects becomes too risky and difficult to justify. Increased costs without a corresponding rise in revenue have sparked developers to cancel projects.

The 'Levelized Nominal Price' represents the average revenue per unit of electricity generated over the lifetime of an entire project, without accounting for inflation – essentially, it reflects the nominal value of the revenue (Table 1). In contrast, the 'Inflation-Adjusted Price' considers inflation, allowing for a more accurate comparison of revenue across different periods. Out of the six selected projects, three have been canceled, two were halted/in the reviewing stage, and only one is on track to be completed by 2026 (Table 2). Projects with comparatively lower PPA prices in 2023\$/MWh, like New England Wind and SouthCoast Wind, encountered severe financial challenges with slimmer profit margins (as of December 2023, both projects have been canceled). In a June 2023 testimony, SouthCoast Wind said "While [we] have pursued, and [are] open to other solutions, and even factoring in potential tax incentives; termination, and payment of a financial penalty for termination, has become the prudent commercial course to realize the Project." (SouthCoast Wind 2023). Meanwhile, projects with higher PPA prices may have had greater flexibility, allowing developers to reevaluate budgeting strategies and explore alternative sourcing options. The divergence in outcomes underscores the critical impact of PPA pricing on the viability of projects in today's market.

Table 1: Power Offtake Agreements for Select US OSW Projects. Data was downloaded from the United States Department of Energy Offshore Wind Market Report: 2023 Edition.

Project Name	Year Awarded Lease	Size of Contract (MW)	Levelized Nominal PPA Price ($/MWh)	Inflation-Adjusted Price (2023$/MWh)	Cost Difference ($/MWh)
Revolution Wind	2013	400	99.5	115.4	15.9
		200	98.4	114.1	15.7
		104	98.4	114.1	15.7
New England Wind	2015	800	79.8	85.4	5.6
		1232	72	77	5
SouthCoast Wind	2019	400	58.4	63.7	5.3
		404	58.4	63.7	5.3
		1232	77	82.4	5.4
Empire Wind 1	2017	816	99	114.8	15.8
Beacon Wind 1	2019	1230	118	126.3	8.3
Ocean Wind 1	2016	1100	116.8	135.5	18.7

Table 2: Status of Selected US OSW Projects, as of December 2023

Project Name (Developer(s))	State	Status (as of December 2023)
Revolution Wind (Ørsted, Eversource)	RI, CT	Ongoing (delayed) – final investment decision (FID) taken on October 31, 2023 (Ørsted 2023). Offshore construction is expected to start in 2024. Higher tax credits were cited to have saved the project from cancellation (Ørsted 2023).

New England Wind (Avangrid)	MA	Canceled in September 2022 – unsuccessful in renegotiating higher PPAs, Avangrid will pay a $16M penalty to cancel contracts to sell Connecticut power from the Park City Wind project (Crowley 2023). The developer plans to re-bid the project at a higher price (Crowley 2023). Previous plans were to delay Park City from coming online in 2027 instead of the original state date of 2025.
SouthCoast Wind (Shell, EDP Renewables, Engie)	MA	Partnership exit, canceled in October 2023 – Shell exited PPA, agreeing to pay a penalty rather than face rising costs for building the project (Nasralla and Bousso 2023). Petition filed with the Massachusetts Department of Public Utilities to pay $21M for cancelation of agreement with National Grid, one of the three offtakers (Massachusetts Department of Public Utilities 2023).
Empire Wind 1 (Equinor, BP)	NY	Reviewing – petitions submitted for PPA renegotiations and additional funding were denied by the New York Public Service Commission (New York Public Service Commission 2023). Developers are reviewing the NYPSC decision before taking the next steps.
Beacon Wind 1 (Equinor, BP)	NY	Reviewing – petitions submitted for PPA renegotiations and additional funding were denied by the New York Public Service Commission (NYPSC) – the request was for the strike price to increase from $118 to $190.82/MWh (New York Public Service Commission 2023, Beckman 2023). Developers are reviewing the NYPSC decision before taking the next steps.
Ocean Wind 1 and 2 (Ørsted)	NJ	Canceled in October 2023 – announcement of the discontinuation of development for Ocean Wind 1 and 2 as a consequence of supplier delays and rising interest rates (Ørsted 2023). Related impairment costs could amount to as much as $5.58B (Gronholt-Pedersen 2023). Ørsted announced that $2.8B of its OSW losses originated from now-canceled Ocean Wind (Crowley 2023).

Key Finding 3: Given current development progress, all states are unlikely to meet their OSW targets in the near term.

With a growing number of developers delaying or abandoning their projects, states will likely not be able to reach their 2030 - 2040 OSW targets. Renegotiation efforts and announced delays also hinder the Biden administration from achieving their 30GW of OSW capacity by 2030 goal. Although it is expected that over 380 GW of new OSW, capacity will be added in the next decade, bringing total capacity to 447GW by the end of 2032, only ⅓ of this projected new volume will be added between 2023 and 2027 (Williams and Zhao 2023).

As of December 2023, all regulators have declined to waive existing PPAs – however, they have allowed projects to rebid in future OSW solicitations that would include inflation-adjusted PPAs. In an October 2022 statement, New York State Public Service Commission Chair Rory Christian said, "The requested amendments to the [Beacon Wind and Empire Wind] contracts would have provided adjustments outside of the competitive procurement process; such relief is fundamentally inconsistent with long-standing Commission policy" (New York State Public Service Commission 2023). New York has a target of adding 9GW of cumulative OSW power by 2035 and previously contracted 4.3GW in its first two solicitations (Figure 2). Nonetheless, 95% of the state's contracted capacity is already at risk (Jain 2023). Other states, including Massachusetts, Connecticut, and New Jersey, also have high proportions of the contracted pipeline at risk of delay or cancellation. States now face the challenge of protecting ratepayers and ensuring competition in the procurement process, all while still achieving critical state goals. To reach affordable clean energy, it is crucial to lower the LCOE of OSW in the US.

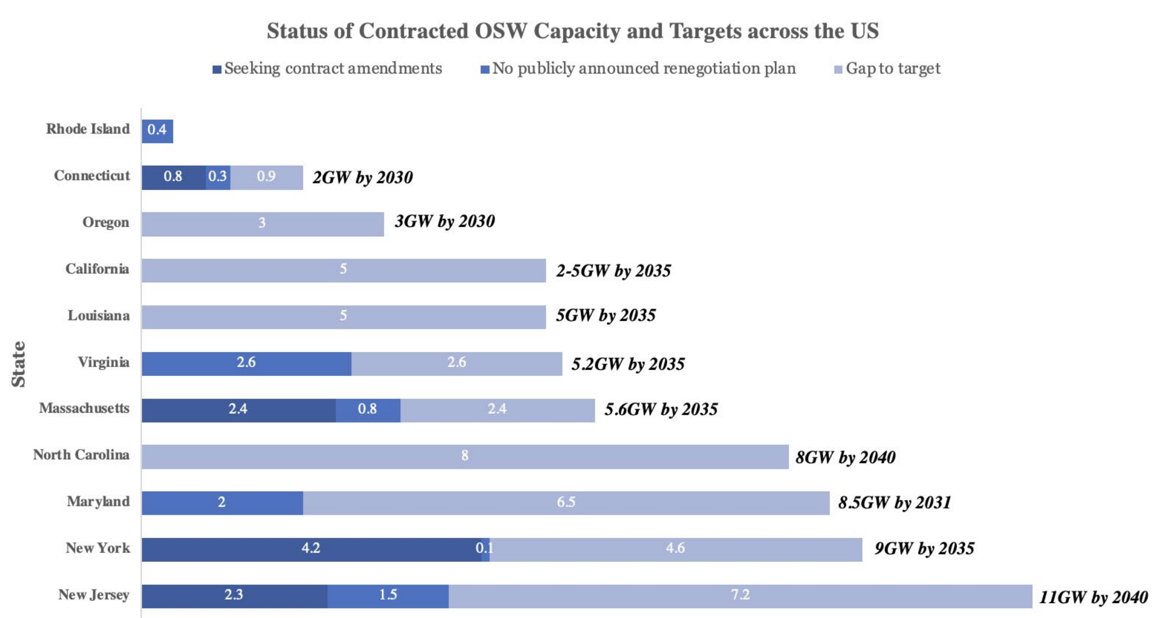

Figure 2. Status of Contracted OSW Capacity and Targets Across the US (Jain 2023).

Recent Barriers to US Offshore Wind Development

To further understand the underlying causes of the current market outlook, this section provides greater insight into the intricacies of the recent challenges facing OSW's economic viability and development. Some barriers were touched upon in previous sections, while others will be introduced. Barriers will be grouped into 3 overarching themes; nonetheless, it is important to recognize that these barriers are in interplay and therefore are not confined to a single theme.

1. *Macroeconomic and Geopolitical Environment* – which includes supply chain disruptions, high inflation, and rising interest rates
2. *Construction and Operations* – which includes lack of domestic infrastructure and labor
3. *Seabed Lease Bidding Behavior and Structure* – which includes aggressive seabed lease bidding prices and required upfront payments

1. Macroeconomic & Geopolitical Environment

Following the COVID-19 pandemic and the Russo-Ukrainian War, global supply chains became overburdened. Sustained high consumer spending and the slow reopening of manufacturing facilities forced the prices of commodities and products to continue increasing. As the US OSW market relies on overseas production, a volatile and disrupted supply chain made procuring raw materials more difficult and sent project costs soaring. As compared to pre-COVID-19, the average price of seven key critical minerals, excluding steel, needed to construct a wind turbine has increased by 93% in 2023 (Ferris 2023). Prices for steel and iron, which account for the large majority of materials used in an OSW project, have remained higher than pre-pandemic levels (Webster and Carpen 2023). Cost inflation means higher commodity prices, which translates to higher manufacturing costs. For example, the cost of a wind turbine increased by nearly 38% in the span of two years, from 2021 to 2023 (Ferris 2023). Additionally, with slower supply chains and isolation mandates, projects were forced to delay construction. Since many developers had negotiated PPA/OREC agreements with states before the supply chain crunch and cost increases hit, the unexpected challenges in project costs and development rendered several projects financially unfeasible.

In March 2022, the Federal Reserve started raising interest rates to counter inflation, exacerbating the impacts of cost inflation (Board of Governors of the Federal Reserve System 2022). As both inflation and interest rates surged, the cost of physical materials and debt went up. For the OSW industry, higher financing costs resulted in 1) less capital supply and 2) increased LCOE for projects. During periods of economic uncertainty, such as rate hikes, institutional investors tend to steer away from high-risk investments like OSW projects. With a reduced influx of funds into the industry, most developers struggled to fund the development of their projects. Even developers with supposedly low exposure to interest rates were not immune to project cancelations. Ørsted originally claimed in their third-quarter 2022 earnings call that they "continue to hold a stable debt position as more than 95% of our bank and bond portfolio are secured with fixed interest rates" (Ørsted 2022). Yet, in 2023, the developer abandoned two of the eight OSW projects it had in development in the US citing challenges with interest rates (Ørsted 2023).

2. Construction and Operations

For the OSW industry, macroeconomic and geopolitical pressures were compounded by industry-specific construction and operational challenges. The US OSW industry faces critical deficiencies, with no Jones-Act compliant wind turbine installation vessels (WTIVs), only 8 commissioned vessels (7 of which are simply crew transfer vessels), and 28 vessels that are announced or under construction (US Department of Energy 2023). Each OSW project, according to American Clean Power Association estimates, requires a minimum of 25 vessels across all project states and takes 2 to 3 years for OSW installation (American Clean Power Association 2021). Wind turbines are sizeable structures; existing OSW turbine blades and rotors of newer turbines can be more than 90 meters and 200 meters long respectively. Given their length, specialized WTIVs are required for installation (Webster 2022). Yet, the construction of these WTIVs represents a significant financial and engineering challenge. A single WTIV could cost at least $500M to construct (US Department of Energy 2023). The shortage of US-built WTIVs compels most projects to opt for foreign-flagged WTIVs, with US-flagged feeder vessels assisting construction (US Department of Energy 2023). To achieve Biden's 30GW by 2030 target, an investment of $8B is needed to further develop port infrastructure and a minimum of 34 additional manufacturing facilities must be built (Shields et al. 2023). Given the constraints of the Jones Act, limited availability of installation vessels, and insufficient manufacturing facilities, it is especially difficult for developers to transport, manufacture, and erect wind turbines in US waters.

In addition to inadequate manufacturing facilities and vessel infrastructure, the lack of skilled labor continues to constrain project development. The National Renewable Energy Laboratory (NREL) estimates that the US OSW industry needs to employ 58,000 full-time workers (in a 100% domestic content scenario) every year between 2024 to 2030 to meet the 30GW by 2030 target (Shields et al. 2023). Nonetheless, in 2021, total employment in the domestic OSW industry was only 877 (Shields et al. 2023). Adding to the low employment levels are the COVID-19 pandemic and isolation mandates which halted construction activities and training of workers. Installation schedules were and continue to be further constrained by the East Coast's whale breeding season, limiting operational windows to a few months, inclusive of vessel transit time (McLean 2023). This logistical challenge places added pressure on developers, requiring them to secure vessels and construct turbines within an already compressed timeframe.

3. Seabed Lease Bidding Behavior and Structure

The combination of soaring seabed lease prices and a front-heavy lease payment structure can pose a large financial challenge and risk for projects. Developers seeking to build an OSW farm must navigate a competitive auction process for seabed leases, overseen by BOEM. During this competitive bidding process, where multiple parties express interest in acquiring a seabed lease, the lease is awarded to the highest bidder, provided that their bid exceeds the fair market return (a minimum bid established to ensure a fair price for the public) (Hansen et al. 2024). BOEM uses a multi-factor auction format – each bid is assessed as the sum of the cash offer from the seabed lease and non-monetary factors (Bureau of Ocean Management 2022). In the 2023 New York OSW Solicitation, proposed projects were weighted "70% price considerations, 20% economic benefits to New Yorkers, and 10% project viability" (New York State Energy Research and Development Authority 2024). As these seabed lease auctions occur at the potential project's outset, developers do not have clear estimates of project costs and future revenue sources. Despite this uncertainty, winners of auctions are required to make significant upfront payments for lease costs (Hansen et al. 2024).

Recent years have witnessed a dramatic surge in both bid and winning lease prices across the US (Figure 4). Two factors, among many, are key drivers of seabed lease price increases: 1) high demand for scarce seabed leases in the US and 2) developer and investor confidence in the OSW industry. For attractive seabed lease areas (which are in areas with developed policy support, high wind resources, and using fixed-bottom technology), developers are bidding large amounts to successfully secure lease areas. Notably, the New York Bight OSW auction in 2022 fetched a record-breaking $4.37B, with the lease costs amounting to 22% of average capital expenditures for OSW projects (Hansen et al. 2024). Of the six leases auctioned off, the highest lease price came out to be $2.64M (in $2022\$/km^2$) (US Department of Energy 2023). The first West Coast OSW auction generated $757M in the same year, showcasing a notable future despite trailing behind East Coast results and market expectations (US Department of Energy 2023).

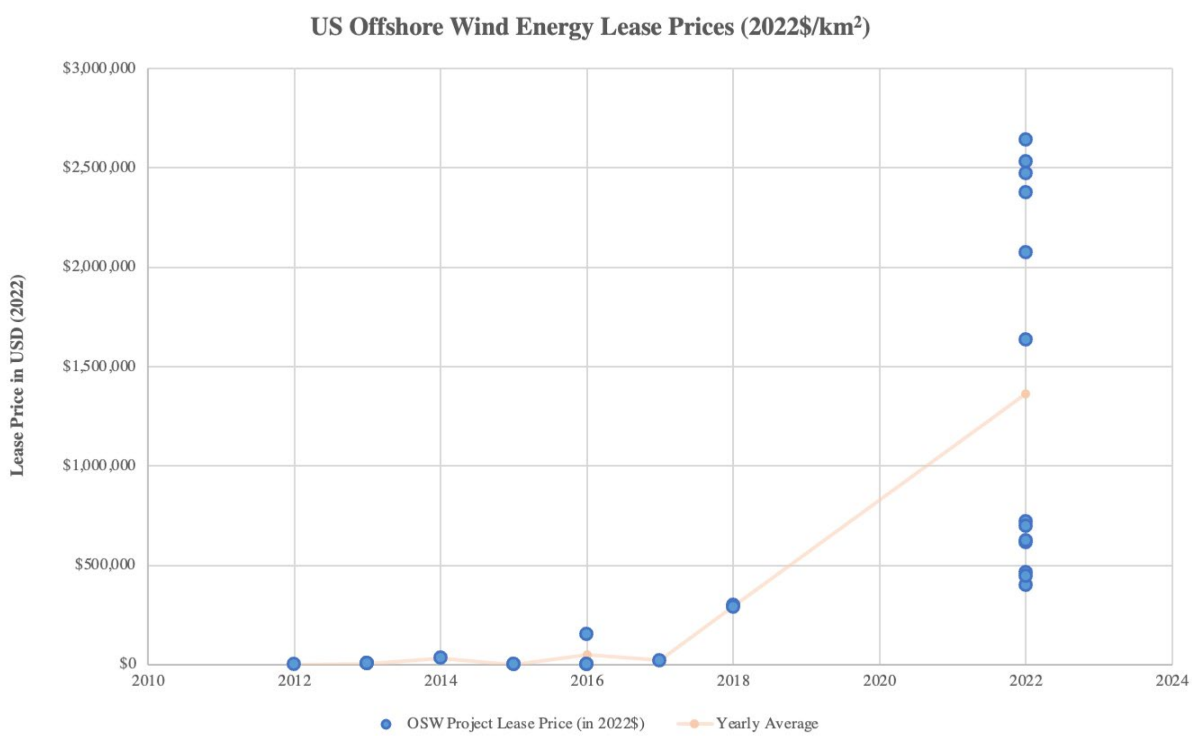

Figure 4. US OSW Energy Lease Prices. Data was downloaded from the United States Department of Energy Offshore Wind Market Report: 2023 Edition.

Entering 2023, developers were faced with unexpectedly high project costs, compounded by already high capital expenditures from soaring lease prices, with no prospect of augmenting future revenues. The confluence prompted the inevitable cancellation of some projects. Although

BOEM is starting to emphasize the use of non-price factors in their evaluation of bids, the reality is price factors will remain the dominant factor in determining which developers secure a seabed lease. Although the economic outlook of the renewable energy markets is improving with moderating inflation and healthy economic growth, the COVID-19 pandemic and its aftermath have set back OSW construction. Given these challenges, policy intervention is necessary to ensure the financial viability of projects and promote OSW development.

Policy Solutions to Advance US Offshore Wind Development

Given the ongoing economic shortcomings and development challenges in the OSW industry, policy intervention is required to address the unique barriers faced by developers. For example, without a strong domestic supply chain, especially for primary component production (e.g., blades, foundations, towers, etc.), OSW projects will remain expensive and unfeasible. In interviews with industry experts, complemented with additional policy research, the following policy opportunities were highlighted as main priorities to alleviate current headwinds and advance US OSW development, presented in no particular order:

1. Strengthening domestic supply chain and infrastructure
2. Improving financing mechanisms and incentives
3. Streamlining the permitting process
4. Building out the transmission network and capacity
5. Expanding tribal resources and community benefits

Specific remarks, as noted in this section of the paper, are based on the perceptions of interviewees. The subsequent analysis and recommended policy solutions include a synthesis of these perspectives.

1. Domestic Supply Chains & Infrastructure

Solution 1: Encourage collaboration by establishing regional clusters aimed at expanding the domestic OSW supply chain and infrastructure

Creating robust regional innovation and supply chain clusters for OSW can help establish a resilient domestic supply chain and infrastructure. The innovative cluster approach involves promoting intensive interactions and stimulating innovative activity among four categories of stakeholders: businesses, academic and research institutions, public authorities, and industry organizations (Fundeanu and Badele 2014). This collaborative framework encourages groups of independent stakeholders to use common facilities, exchange knowledge, and contribute to technology transfer, thereby disseminating valuable information and experience within the cluster (Fundeanu and Badele 2014). Cooperation between firms, driven by potential cost-sharing, has been demonstrated to yield social benefits that may arise without government intervention (Griffin et al. 2015). Moreover, firms operating in supply chain clusters (where firms integrate with partners adjacent to them in the supply chain) exhibit higher levels of performance (Kannan and Tan 2010). As OSW construction and operation are typically carried out regionally, regional clusters can address the key supply chain issues of the region, ranging from manufacturing to delivery.

Expanding the number of regional consortiums, and more importantly, the number of participants in each one, can facilitate the growth of regional supply clusters and domestic supply chains. Early efforts to improve the supply chain have included the Department of Energy (DOE) and the National Offshore Wind Research & Development Consortium releasing a supply chain roadmap to direct efficient and equitable supply chain buildout for OSW (The White House 2023). In 2022, New York, New Jersey, and BOEM also published a plan to coordinate and develop the OSW supply chain, titled "A Shared Vision of the Development of an Offshore Wind Supply Chain" (US Department of the Interior 2022b). In strengthening the domestic supply chain and infrastructure, developers would see improved project economics with cheaper vessel reservation contracts and more port availability.

The US OSW market has a "chicken-and-egg" dilemma with domestic manufacturers unwilling to expand production capabilities without demand certainty, while developers struggle to source domestically produced OSW components and thus turn to foreign manufacturers. Breaking this cycle requires coordinated efforts from policymakers, industry associations, and other relevant stakeholders – manufacturers need credit evidence of a strong and sustainable US OSW market before investing in new, OSW-specific manufacturing. Governments can help by providing regulatory clarity by reinforcing ambitious OSW targets, expanding seabed leasing that generates consistent deployment after 2030, and or creating local content regulations that set a minimum share of domestic suppliers or value for OSW projects (Shields et al. 2022, Van der Loos et al. 2022). Future leasing in the Gulf of Mexico, Central Atlantic, Hawaii, and the Gulf of Maine regions will further call for a domestic OSW pipeline and supply chain (Shields et al. 2022). At the same time, strategic public-private partnerships to ensure innovations enable new investment in domestic facilities and collaborative investment in research and development (R&D) for OSW technology can help bridge the gap between supply and demand. In particular, funding research and development in floating OSW technologies is imperative to unlock the full potential of OSW and guarantee its long-term success. Given that a substantial portion of the seabed in the US is unsuitable for fixed-bottom turbines, being able to commercialize floating OSW technology – particularly by lowering costs of production – is the first step to harnessing the nation's untapped OSW resources (Hansen et al. 2024).

Solution 2: Streamline vessel permitting and incentivize private funding through low-interest loans to support the construction and expansion of ports and vessels dedicated to OSW activities

The shortage of vessels and suitable ports for turbine installation poses one of the biggest risks to deployment. Construction of Jones Act-compliant vessels lags OSW deployment plans, even with high demand for them. It may be useful to introduce a backstop mechanism, which may manifest as financial or regulatory support, particularly during contracting gaps, when ships might not be in use. Such a mechanism would serve to ensure a consistent flow of construction projects for US vessels, mitigating potential disruptions.

In one interview, the respondent noted port development and redevelopment have been a significant bottleneck, primarily attributed to the challenging nature of the upfront investments required. Financial incentives such as low-interest loans could serve a dual purpose: firstly, attracting more private financing from private equity investors, and secondly, spurring ports to invest themselves. The recuperation of costs could be achieved through rent payments made by developers, which are not limited to only offshore wind projects. This approach holds the potential to expedite port development or redevelopment, facilitating a more robust infrastructure for OSW construction activities.

Solution 3: In collaboration with developers, standardize and invest in educational programs to train and retain a skilled workforce capable of supporting the growing OSW industry

Collaboration at the in-state, regional, and national levels is essential to address the current workforce needs and skills gap in OSW construction. To achieve this, it is crucial to bring together local and state governments, developers, labor organizations, educational institutions, and the industry. Some states, such as New York and Massachusetts, have taken the lead by publishing assessments of workforce skills analysis and forecasting future needs in the OSW sector. These assessments serve as a foundation for shaping the structure of training programs. Maryland established the Maryland Works for Wind, a regional consortium fostering partnerships with employers, unions, local workforce development areas, and training providers (Maryland Department of Labor 2024.). Conversely, Virginia has created the Mid-Atlantic Wind Training Alliance hosted by New College Institute and working with Mid-Atlantic Maritime Academy, and Centura College (New College Institute 2020). This alliance aims to offer a diverse range of training courses tailored to the needs of the OSW industry. New York has also created the Offshore Wind Training Institute in partnership with the State University of New York at Farmingdale and Stony Brook University. The University of Massachusetts Amherst (UMass Amherst) is establishing the Academic Center for Reliability and Resilience of Offshore Wind (ARROW) to accelerate reliable and equitable OSW deployment and train a well-educated domestic workforce. ARROW will receive $4.75M over five years from the DOE, Massachusetts Clean Energy Center, State of Maryland, Johns Hopkins University, and Morgan State University (Westbrook 2024).

Although various states have implemented individual workforce initiatives, a significant challenge lies in the lack of collaboration between states. This, in turn, hampers the development of adaptable training programs that can effectively meet the growing workforce demands of the sector. Building regional workgroups and developing standardized training programs may help align the supply and demand of skilled labor for the OSW market. Furthermore, this strategy allows stakeholders to pool resources and leverage collective expertise. Organized labor and community colleges should be at the forefront of executing and supporting these work training programs, addressing labor market and employer needs, advocating for worker rights, and enhancing the skills of workers. Developers must actively work to collaborate with labor unions, education institutions (including Indigenous serving), and government agencies to promote workforce diversity and uphold industry standards. By fostering collaboration, stakeholders can share best practices, coordinate efforts, and streamline the development and implementation of workforce training initiatives.

2. Financing Mechanisms and Incentives

Solution 4: Restructure PPAs and OREC contracts to more accurately reflect project costs and reduce risks associated with long development timeframes

Previously negotiated PPAs often featured simplistic structures, generally involving a fixed price per MWh, and in some cases, a lower-single-digit percentage increase to correct for inflation over time. However, recent project cancellations have demonstrated the limitations of such PPA designs. They are easy to negotiate but insufficient in capturing the risks of market volatility, industry dynamics, and unforeseen events that hinder project construction and operations. Looking ahead, industry leaders must pay much closer attention to the structure of PPAs. Two changes have been brought forward by industry experts: 1) reducing the gap between signing PPAs and permitting through parallel processing, and 2) increasing guidance on market disruption and fallback procedures. By minimizing the time lag between signing PPAs and OREC contracts, securing permits, and accurately projecting construction costs, these refined PPAs take into account more reliable project forecasts and market developments. This, in turn, enables developers and offtakers to negotiate a mutually beneficial PPA that ensures the project is economically viable. Placing PPAs later in the development phase also allows developers to mitigate risks and predict income streams – enhancing project appeal to investors and increasing the likelihood of securing financing (Hansen et al. 2024).

Solution 5: Expand project financing support programs to alleviate the financing obstacles and improve the profitability of projects

Currently, the US government has implemented a range of financing options at the municipal, state, and federal levels to support OSW project financing. In addition to tax incentives administered by the federal government, Clean Renewable Energy Bonds, the Innovative Energy Loan Guarantee Program, and various state funds are vehicles that can finance sustainable development (US Department of Energy 2024). Although tax credits are one of the largest forms of federal finance support for OSW development, a notable hurdle arises as many OSW developers lack sufficient tax liability to capitalize on these non-refundable credits fully (Hansen et al. 2024). A solution to this challenge is allowing unused tax credits to be transferable to any entity with corporate income tax liability. As such, different entities can support OSW projects without becoming tax equity investors (Hansen et al. 2024).

Adopting central procurement could be another effective way to bolster the financing of OSW projects by providing developers with predictable revenue streams. Projects with secured reliable and competitive supply agreements through central procurement mechanisms may boost investor confidence in the project's financial viability and risk profile – this, in turn, could help attract capital investment, lower financing costs, and unlock additional sources of funding from public and private stakeholders. With Governor Newsom signing AB 1373 into law and NYSERDA in charge of procurement on behalf of the state, states endowed with OSW resources could consider emulating this model (Micek 2023).

3. Permitting Processes

Solution 6: Support multi-agency coordination between and within state and federal government agencies – in particular, the National Oceanic and Atmospheric Administration (NOAA) and the Bureau of Ocean Energy Management (BOEM)

Several interviewees highlighted the importance of fostering close coordination between the state and federal governments to minimize delays and maintain consistency in permit filings across states. Additionally, it was pointed out that structurally conflicting responsibilities between NOAA and BOEM, in part, stemming from differing missions and priorities, can result in disagreements over environmental assessments. Ultimately, the prolonged environmental assessment contributes to additional delays in the permitting timeline for OSW projects. NOAA's responsibility is marine resource conservation and management, which prioritizes the protection of marine species; on the other hand, BOEM facilitates and encourages OSW energy development on the Outer Continental Shelf (OCS).

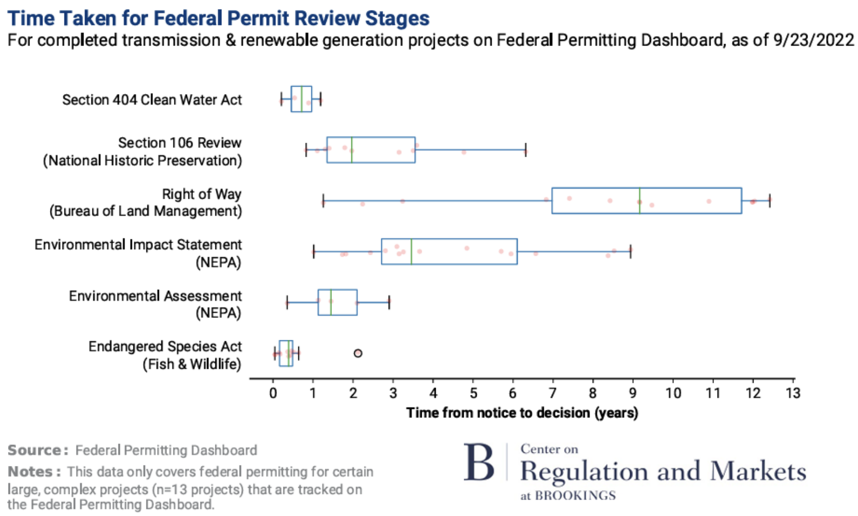

Figure 3. Time Taken for Federal Permit Review Stages (Sud et al. 2023)

Permitting is an intensive process for developers. Several permits are required and permit timelines can vary greatly. For example, site assessments of renewable energy projects can take up to five years (Russell et al. 2021). To tackle this issue, the White House could establish an interagency task force, operating across NOAA and BOEM, to oversee the streamlining and enforcement of permitting. By centralizing coordination efforts to minimize the risk of miscommunication and working towards establishing unified guidelines for environmental assessments and permitting procedures, the task force could provide consistency and efficiency to developers, reducing existing permitting bottlenecks and the likelihood of delays due to different requirements by NOAA and BOEM. This follows a similar model of one-stop-shop (OSS) permitting, an approach used in many mature European markets, whilst still adhering to the US laws. Following German and British OSW strategies, housing permitting authorities within a single agency, at the state and or federal level, may help detangle the complex OSW regulatory web and enable large-scale strategic processes in the future (Webster and Carpen 2023). Interestingly, US Senator Sheldon Whitehouse recently released a draft discussion of the COLLABORATE (Create Offshore Leadership and Livelihood Alignment by Operating Responsibly And Together for the Environment) Act, which includes provisions to create a Director of Offshore Wind in the White House and requires meetings between BOEM and other federal agencies to quicken project delivery (Senator Sheldon Whitehouse 2024).

Environmental assessments are particularly time-intensive and expensive, increasing the cost of constructing an OSW project for developers. The time needed to complete an environmental assessment varies depending on the type of information needed about a particular OSW project, the project's complexity, potential impacts on coastal resources, and the degree of coordination with other permit review processes. Performing concurrent permitting reviews between federal agencies and state coastal management agencies, in addition to supporting multi-agency coordination, shortens the permitting timeline while preserving the quality of environmental assessments.

Solution 7: Reform the Outer Continental Shelf Lands Act (OCSLA) for better transparency and provide certainty for developers and the industry

Enacted in 1953, OCSLA was designed to facilitate the leasing, exploitation, and development of offshore mineral resources on the OCS. Although originally tailored to regulate oil and gas, this legislation serves as one of the most important governing statutes for BOEM (Bureau of Ocean Energy Management 2024). BOEM issued a proposed rulemaking to create a new leasing system for OSW projects in January 2023; however, despite this progress, many factors in OCSLA still require modernization (Bureau of Ocean Management 2024). For example, the DOI does not publish a 5-year schedule of renewable energy lease auctions which leads to uncertainty and little transparency for relevant stakeholders – developers, financing agencies, and communities – to plan in a timely manner (Office of the Law Revision Counsel of the United States House of Representatives 2017). Legislative amendments could be introduced, explicitly incorporating provisions for OSW leasing and development (to bring OSW on a fairer footing with the treatment of OCSLA for offshore fossil fuel production) that address wind resource assessments, transmission infrastructure, and environmental impact assessments. OCSLA could also be expanded to outline 1) the criteria by which BOEM's evaluation and planning of potential wind energy areas, and 2) the litigation and judicial review process for OSW projects, providing greater certainty and defined parameters to industry stakeholders.

Solution 8: Engage with indigenous and tribal communities throughout all permitting steps to ensure tribal knowledge, priorities, and interests are incorporated into the management of OSW projects

Indigenous and tribal communities possess deep-rooted connections with the ocean and coastal regions, which form integral parts of their cultural, spiritual, and economic identities. OSW development can have a wide-ranging impact on Indigenous and tribal communities, their territories, and traditional resources. Projects that coincide with traditional fishing areas can hurt tribal members who rely on subsistence fishing. Nevertheless, while government agencies are obligated to consult with tribes, and BOEM leases may require developers to consult, *existing legislation* does not mandate that developers engage in consultations with tribes at any phase of the development process. Many tribes have voiced concerns over potential environmental damage and threats to cultural heritage. In 2023, the National Congress of American Indians called for a moratorium on OSW development, insisting on greater protection of tribal interests (Dlouhy 2023).

Indigenous and tribal communities should be included and directly involved in the decision-making process for OSW development, starting with permitting. BOEM and developers ought to consider conducting comprehensive consultations with tribal leaders, appointing tribal representatives to be included in evaluating environmental impact assessments, and establishing opportunities for co-management and cooperative agreements. Moreover, to ensure these communities have the capacity and information they need to meaningfully engage and benefit from offshore wind development, they should also be provided with early access to draft documents and pathways to incorporate their priorities into permit and mitigation requirements.

4. Transmission

Solution 9: Identify feasible, cost-effective, and long-term points of interconnection to integrate into the existing grid structure

Points of interconnection (POIs) support the integration of OSW energy into the broader electrical grid, enabling generated electricity to be transmitted from farms to onshore substations, distribution networks, and landlocked states. The existing onshore transmission grid has limited capacity, and thus additional POIs must be built to accommodate the increasing power output anticipated from upcoming OSW projects. Developers are growing increasingly concerned with transmission – the current "project-by-project" or "build-as-usual" approach will require costly upgrades and POIs near coasts are already limited (Horwath and Rack 2021). In a Jan 2023 concept paper, several state agencies wrote that "continued interconnection at suboptimal POIs may lead to either curtailment or to expensive onshore reliability upgrades that will be borne by ratepayers." States, in collaboration with grid operators, transmission owners, and other relevant entities, should work to identify the most applicable POIs for onshore and offshore development. In addition, one interviewee emphasized the importance of selecting POIs for OSW interconnection with a consideration beyond immediate requirements, urging a thoughtful assessment of future transmission needs.

Solution 10: Establish effective interregional planning processes to assess the full set of transmission needs and identify long-term multistate solutions

Multistate collaboration to establish interregional planning processes will help develop integrated transmission solutions and support state efforts in mitigating and avoiding environmental impacts. Beyond environmental benefits, well-planned interregional transmission could lead to reduced cost, congestion relief, increased reliability, and fewer curtailments of renewable generation. To initiate this process, states and grid operators can begin by proactively evaluating and forecasting both regional and interregional transmission needs – including future generation, load profiles, and generation mix. Subsequently, federal and state agencies can work together to assess the relevancy and suitability of interregional solutions, taking into account cost-effectiveness and feasibility, in addressing such needs. One interviewee stated that a successful interregional planning process may involve incorporating scenario-based planning for projects and evaluating a wider variety of benefits in cost-benefit analysis.

5. Tribal Resources & Community Benefits

Developers and regulatory agencies must prioritize fostering equitable partnerships with indigenous and tribal nations to protect tribal sovereign interests and ensure the long-term success of OSW development. This collaboration can manifest in various forms – for example, incorporating tribal perspectives in project planning processes, dedicating resources to compensate tribes for the use of tribal land and resources, and developing robust community and workforce benefit programs. By engaging in meaningful dialogue with indigenous and tribal nations, policymakers and developers can also gain valuable insights into traditional ecological knowledge, enabling them to minimize the environmental impacts of OSW projects. Fostering partnerships between developers and host communities also offers an opportunity to address challenges faced by local marginalized and disadvantaged groups. Tribal groups have been advocating for a more direct role in OSW development decision-making as well as early access to planning documents to appropriately and sufficiently address tribal concerns (Hoff 2024).

BOEM has initialized the process of increasing community benefits through granting bidding credits to developers making a monetary contribution to workforce training and or domestic supply chain development programs (Bureau of Ocean Management 2022). Another mechanism of formalizing commitments to host communities is through Community Benefits Agreements (CBAs), which create legally binding contracts between developers and community groups that outline the range of community benefits the developer will provide in exchange for community support for an OSW project (Mirza et al. 2023). Since CBAs typically outline the specifics of proposed benefits and require engagement with community members, they may be a more comprehensive tool to ensure projects contribute positively to the well-being of those they impact. CBA provisions may include funding for clean energy apprenticeships for tribal and indigenous people, agreements to pay living wages and additional benefits, or initiatives to build affordable housing for low- to moderate-income workers.

DISCUSSION

Despite the prevailing macroeconomic and geopolitical environment, which has exerted financial pressure on firms in both the short and medium term, OSW remains poised to make significant contributions to the US renewable energy targets. As shown by the six case studies, current projects have faced substantial delays in reaching CODs, and escalating costs. States are also struggling to meet their OSW goals due to sluggish deployment rates. Realizing the full potential of OSW and fulfilling state targets will require overcoming numerous barriers, from maritime infrastructure constraints to long permitting processes, and ensuring community benefits. Consequently, industry actors need to undertake a comprehensive analysis of the sector's dynamics, uncovering the root causes of the current financial, operational, and regulatory distress experienced by developers.

Assessing the market outlook of OSW projects and identifying their challenges have revealed valuable insights to help inform policymakers, industry leaders, and other relevant stakeholders. As more states embrace and expand OSW initiatives, understanding these challenges and the tools that can be implemented to overcome them becomes paramount to fostering resiliency and sustainable industry growth. Undoubtedly, the disruptions caused by the COVID-19 pandemic, alongside macroeconomic and geopolitical shifts, have added layers of complexity to OSW development. Yet, research into the impacts of these factors remains limited due to their recent occurrence. Through this study, I aim to address the research gap and highlight existing issues in policy and regulatory frameworks that hamper OSW development and viability. Findings serve to elucidate the growing pains in an emerging industry, emphasizing the importance of stakeholder collaboration and policy design to support and finance renewable energy.

Implications of the US Offshore Wind Market Outlook

With multi-year delays in CODs for OSW projects, these lengthened development timelines have exceeded those observed in other sectors of the US renewable energy field. Between January and June 2022, approximately 20% of planned solar photovoltaic capacity experienced delays, while the majority remained on or ahead of schedule (Antonio & Hodge 2022). In most cases, reported delays of utility-scale solar projects were limited to only six months or less (Antonio & Hodge 2022). Despite all energy projects being subject to broad economic factors, supply chain limitations, elevated commodity prices, and labor shortages, however, certain sectors – notably solar energy – have exhibited greater resilience. The solar industry's maturity and adaptability may be attributed to its well-established supply chain networks, relatively straightforward installation processes, and technological advancements that have enhanced solar panel efficiency in conjunction with reducing installation costs. Both OSW developers and policymakers should look to solar and other renewable energy industries to tailor best practices and potential policy interventions.

The East Coast OSW market grew too quickly – developers who previously signed PPA agreements have now claimed their projects are no longer financially viable (US Department of Energy 2023). Whilst the outlook of East Coast projects is overwhelmingly negative – given COD delays, surging costs, and project cancellations – interviewees have expressed that West Coast projects appear to be faring better. California faces many infrastructure and workforce challenges; however, state agencies have the opportunity and time to learn from East Coast projects and adjust their policy actions accordingly. West Coast projects face the additional technical and financial challenges of building floating OSW farms due to topography constraints (all East Coast projects were fixed-bottom turbine farms). Floating OSW farms, where turbines are built on floating structures instead of directly on the seabed, are currently more expensive than fixed-bottom ones, have only been built for small-scale farms, and are not expected to reach commercialization until 2030 (Williams and Zhao 2023).

Overcoming Barriers to OSW Development & Priorities for Policy Solutions

In navigating the barriers facing the US OSW industry, industry actors and policymakers must align priorities and co-design policy solutions to facilitate the success of forthcoming projects. Recognizing the diverse landscape of infrastructure, environmental conditions, regulations, and energy demands across states, the adoption of a "one-size-fits-all" policy approach for OSW proves unrealistic. However, amidst this diversity, there are areas where states can enhance their policy support: domestic supply chain and infrastructure, financing mechanisms and incentives, permitting, transmission, and tribal resources and community benefits.

The National Renewable Energy Laboratory (NREL) estimates at least $22B of investments into ports, large installation vessels, and major manufacturing facilities will be needed to achieve the 2030 target (Laurie 2023). Significant gaps exist in US OSW manufacturing, port, vessel, and workforce infrastructure. In 2023, the US Department of Energy reported that to install and operate 30GW of OSW, 5 WTIVs would be needed – however, as mentioned in *Recent Barriers to US Offshore Wind Development*, there are no US-built, US-owned, and US-crewed WTIVs operating (Dominion Energy is building the *Charybdis*, expected to be completed in late 2024 or early 2025) (US Department of Energy 2023, Musial et al. 2023, Bulijan 2023). Efficient domestic supply chains and infrastructure can dramatically lower construction costs for developers, enhancing the economic viability of projects. Interviewees emphasized 1) the backlog of vessels being built – in particular, operation and maintenance (O&M) vessels, crew transfer vessels (CTVs), and service operating vessels (SOVs) and 2) the importance of investing in shipyards and ports to increase OSW development in the US. The construction and expansion of maritime infrastructure – namely ports, construction, and maintenance vessels – is essential to support the assembly and installation of OSW turbines at sea.

The current structure of project financing, where offtake contracts are set and locked before the project is near completion, has made OSW profitability difficult (Hansen et al. 2024). Given the lengthy development timeline of OSW projects, developers actively use project financing – a specialized funding mechanism that involves securing funds based on future cash flows generated by the project (Hansen et al. 2024). However, in the dynamic landscape of the OSW industry, the traditional approach to financing is facing increasing challenges. A fundamental shift in financing strategies at the developer, state, and federal levels is crucial to ensure the economic viability of these projects and the sustainable growth of the industry.

Clearing regulatory and administrative hurdles in the permitting process is also critical to deploying OSW at speed and scale in the US. Defining reliable standards can reduce risks, provide planning certainty, and enable a less arduous and costly permitting process for both developers and government agencies. Effective interstate electric transmission is the backbone of a swift buildout of OSW projects. With limited network availability, costly upgrades, and long interconnection queues, transmission was mentioned by all interviewees as one of the biggest challenges facing the OSW industry in the near and long term. Transmission solution planning requires extensive coordination among grid operators, developers, states, and federal agencies; modest delays in strengthening and expanding the existing transmission grid will limit the potential for OSW projects to fully contribute to the energy transition.

Drawing insights from interviews with industry experts and assessments performed by private and public entities, the primary concerns for the OSW industry can be distilled into three key areas: 1) onshore transmission and grid expansion, 2) the development of maritime OSW vessels, and 3) training for skilled labor (Lefevre-Marton et al. 2019, US Department of Energy 2023, New York Offshore Wind Alliance 2024). These issues demand significant time and financial investments, underscoring the need for prioritization in policy innovation and implementation. Indeed, the first deployment of a US WTIV is slated to enter service later than initially anticipated (Bulijan 2023). By directing attention to these critical priorities now, policymakers can establish the groundwork for long-term growth and project success in the industry.

Limitations and Areas for Further Study

The limitations of this study include the geographical concentration and scope of my case studies, the evolving nature of market outlooks, and constraints associated with publicly available data. Despite efforts to gather comprehensive data and insights, there are limitations to focusing on specific geographical clusters where six projects are concentrated. Notably, the choice to concentrate on East Coast projects due to maturity and data availability inadvertently excludes insights from the West Coast and other US regions, where regulatory environments and project characteristics may differ. As such, the case studies may not fully encapsulate the diverse spectrum of challenges confronting the OSW sector, thereby restricting the generalizability of findings to broader contexts. Moreover, rapid changes to market conditions, regulations, and technological advancements add to the complexity of providing definitive assessments of the barriers to OSW development. For example, although the Vineyard Wind 1 offshore wind farm experienced financial difficulties in recent years, it commenced operations in early 2024, illustrating the dynamic nature of projects (Holden 2024). Lastly, reliance on publicly available data sources presents its own set of challenges, including potential incompleteness or lack of granularity. As such, there may be other factors that have led to project challenges and poor economic viability. Restricted access to proprietary data and confidential information held by key industry stakeholders – most notably developers and policymakers – hinders the ability to validate findings. Future research efforts should aim to expand the geographical scope of case studies, incorporate diverse perspectives from stakeholders, and explore alternative data sources and methodologies to enrich the analysis. Other research topics to be explored include evaluating the impacts of COVID-19 and macroeconomic events on other relatively mature renewable energy sectors (e.g., solar and hydro).

Broader Implications

Addressing the multifaceted challenges facing the US industry requires a coordinated and collaborative effort among industry stakeholders, policymakers, and regulatory bodies. By strengthening stakeholder engagement, tribal involvement, and public-private partnerships, joint actions can be taken to bolster regional economic resilience and OSW initiatives. Industry actors must work together to align interests, formulate coordinated agendas, and resolve industry-wide challenges. The findings of this study hold relevance for policymakers and developers, offering insights to shape potential policy solutions, guide investment priorities, and inform strategic planning for future projects. As the European OSW industry attains technological and commercial maturity and China emerges as a frontrunner in wind turbine technology and costs; the future role of the US in the OSW sector hinges on the discernment and efficacy of its decision-makers in embracing policy adaptation and innovation (DeCastro et al. 2019).

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