Assessing the Economic Impacts of Developing the Port of Sheet Harbor into an Offshore Wind Hub

Prepared for:

The Offshore Energy Research Association

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Revision	Prepared	Reviewed	Date	Comment
DRAFT	Justin Meyers	Blair MacDougall	March 22, 2021	Draft submitted for review and feedback
Revision 2	Justin Meyers	Blair MacDougall	April 7, 2021	Final Report Submitted

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Tables & Figures

1. Introduction

On February 22, 2021, Waterford Energy Services Inc. (WESI) began work on the subject study awarded by the Offshore Energy Research Association (OERA) in the context of a collaborative program funded by the Nova Scotia Department of Energy and Mines. In accordance with OERA's request (RFP) released on Feb. 1, 2021 and the subsequent proposal submitted by WESI on Feb. 12, 2021, this study set out to deliver five distinct objectives. These objectives are described as follows:

Objective 1:
To provide a comprehensive summary of the current and future state of the offshore wind (OSW) industry in the northeastern US with a particular focus on areas and projects where developers may realize a benefit by supporting construction from the Port of Sheet Harbor (POSH), Nova Scotia.

Objective 2:
To perform an assessment of the current and planned port facilities and vessels available (and capable) of supporting offshore construction for the OSW industry in the northeastern US. In doing so, the aim was to present an analysis of the US capacity against the expected regional volume of offshore wind construction. Key considerations for this component of the study were the unique technical specifications required of ports and vessels to effectively support offshore wind construction projects and, the limitations that would be imposed on the use of specialized foreign vessels for the projects by virtue of the US's Merchant Marine Act of 1920, more commonly referred to as "The Jones Act".

Objective 3:
To summarize net regional economic benefit experienced through the recent staging of wind turbine generators (WTG) for Dominion Energy's 'Coast of Virginia Offshore Wind' (CVOSW) Pilot Project in Halifax Harbor in 2020. This piece was to include an assessment of potential similar and/or additional benefits that would be realized in using Sheet Harbor as an Offshore Wind support hub for future projects in the northeastern US.

Objective 4:
To describe realistic scenarios defining what percentage of the US offshore wind construction demand would be serviced utilizing the proposed Sheet Harbor base.

Objective 5:
To provide, for each scenario produced by 'Objective 4', a realistic prediction of the regional economic benefits that would result by virtue of an Offshore Wind supply base at Sheet Harbor.

Drone Survey
In addition to these five main study objectives, WESI proposed to deliver material from a Drone Survey of the facilities at Sheet Harbor to be used for future marketing, engineering, and planning purposes. The survey was performed by WESI's drone services partner Aerovision Canada (AVCI) on March 17, 2021. A sample of material generated by the survey is provided in section 12 of this report. Additional digital images and renderings will be made available to the OERA following further discussions and refinements.

2. Scope

Conclusions have been drawn by the assessment of US ports for wind project staging and, US vessels that would support offshore installation. For ports, only key criteria (designated as 'Tier 1' further in this study) have been considered. This point is being made to clarify that there are other factors that can have influence over port selection that are not included or considered in this study's comparisons. Specifically, facilities, equipment, work force, union impact, accommodations, and other criteria, have not been assessed. Potential US manufacturing is however discussed briefly.

This study takes a "free market" approach and does not address impacts that may be had by protectionist regulations, policies, or other requirements for local benefits in the US. In achieving the results described above, WESI has performed an objective technical analysis. By making reasonable and justified assumptions and analyzing available technical and cost information, this study has aimed to determine whether there is a basic economic value proposition to be made to developers for the use of the Port of Sheet Harbor in support of US OSW projects.

In the case study section, which compares overall costs and installation schedules associated with use of the POSH to those operating out of US Ports, any impact that would be seen in either case as the result of federal, provincial, and state tax regimes have not been factored in.

The variety in arrangements that may exist from state to state between developers, investors, governments, utilities, rate payers, etc. have not been explored such to determine what implications those details could have on the study results. For example, as this report touches on briefly, there are unique investment, cost sharing and power purchase aspects of the Dominion Energy Power Project that have justified the construction of the first US Wind Turbine Installation Vessel (WTIV). This report does not compare those aspects to other projects to identify similar or different arrangements.

Finally, reference is made to Section 11, "Other Opportunities". This section offers insight to aspects of future OSW installation activities that have not been fully researched in this study and therefore, should be studied in greater detail as opportunities for Nova Scotia.

3. Approach and Method

The core team for this study was comprised of the following:

- Justin Meyers – WESI Project Engineer
- Blair MacDougall – WESI Project Sponsor
- Marcus Moore – Offshore Wind Installation Subject Matter Expert Offshore Renewable Energy Construction Advisors (ORECA) Ltd.

Supporting the core team were the following additional resources who performed research, provided insights, documentation and previous or existing study material:

- Saitec Offshore Technologies – WESI's Strategic Partner for Floating Wind applications
- Kalene Chandler – WESI Naval Architect Engineer
- Shan Chen – WESI Project Advisor
- Marie Andrews – WESI Account Manager
- Lyall Collins – WESI Corporate Controller
- AeroVision Canada (AVCI) – Drone Survey and Imagery
- Aegir Insights
- Business Network for Offshore Wind (BNOW)
- US Offshore Wind
- NS Business Inc.

WESI's access to this array of internal and external support in combination with interviews plus extensive public data analysis, comprised the study's initial data gathering and information review phase.

As the required information and existing studies were ingested by the core team, assumptions and bases for calculations and predictions were agreed. In many cases throughout this process, industry contacts were consulted to answer specific questions, supply specific data or, validate assumptions made. In all analyses, predictions, assumptions, and calculations have been done objectively and, in many cases, in ways that may favor the use of US ports instead of Sheet Harbor. This was done to avoid bias and add a measure of conservatism to the results. Sections 14 and 15 provide a complete listing of all sources and references used through the course of this study.

The POSH holds many advantages attractive to OSW developers and installation companies. These features include no height restrictions, ample laydown area, sufficient draft and no unusual tide considerations. Other ports in the region may also avail of opportunities presented by US OSW projects but in most cases do not offer all the advantages of POSH.

4. List of Acronyms and Abbreviations

AVCI - Aerovision Canada
BNOW - Business Network for Offshore Wind
BOEM - Bureau of Ocean Energy Management
CAPEX - Capital Expenditure
CBP - Customs and Border Protection
CIP - Copenhagen Infrastructure Partners
COD - Commercial Operation Date
COP - Construction and Operations Plan
CT - Connecticut
CVOSW - Coast of Virginia Offshore Wind
DMME - Department of Mines Minerals and Energy
DOE - Department of Energy
DWW - Deepwater Wind
e.g. - For example
GW - Gigawatt
Hs – Significant Wave height
i.e. - That is
km - Kilometre
km/h - Kilometres per hour
kW - Kilowatt
LCOE - Levelized Cost of Energy
LLC - Limited Liability Company
M - Metre
Mass. - Massachusetts
MD - Maryland
MM USD - Million United States Dollars
MW - Megawatt
NBMCT - New Bedford Marine Commerce Terminal
NJ - New Jersey
NPT - Non-Productive Time
NREL - National Renewable Energy Laboratory
NSBI - Nova Scotia Business Inc.
NY - New York
OERA - Offshore Energy Research Association
ORECA - Offshore Renewable Energy Construction Advisors
OSW - Offshore Wind
POSH - Port of Sheet Harbor
RFP - Request for Proposal
RI - Rhode Island
ROI - Return on Investment
SBMT - South Brooklyn Marine Terminal
SPMT - Self-Propelled Modular Transporter
US - United States
VA - Virginia
WESI - Waterford Energy Services Inc.
WTG - Wind Turbine Generator
WTIV - Wind Turbine Installation Vessel

5. Executive Summary

There is ample evidence to support significant OSW "window of opportunity" for Atlantic Canadian ports such as Sheet Harbor. This is due in part to an imminent surge in OSW construction activity in the northeastern US that seems apparent when analyzing the agenda and commitments already made by the recently installed US Federal Government and President Biden. The information collected makes it clear that approximately 20 projects across 8 northeastern states for a total of 19.5 GW of offshore wind power contribution are ready to move forward. Nearly 6.5 GW of that power has already been purchased or agreed for offtake by various states. This data is evidence enough of the activity soon to be realized without considering the additional power required to meet state targets for 2035 and the large, uncontrolled lease areas set to be auctioned later this year.

On February 22, 2021, Waterford Energy Services Inc. (WESI) began work on the subject study awarded by the Offshore Energy Research Association (OERA) in the context of a collaborative program funded by the Nova Scotia Department of Energy and Mines. In accordance with OERA's request (RFP) released on Feb. 1, 2021 and the subsequent proposal submitted by WESI on Feb. 12, 2021, this study set out to deliver five distinct objectives.

1. To provide a summary of the current and future offshore wind industry in the northeastern US
2. To present an assessment of the currently available US OSW construction ("staging") port infrastructure and vessel fleet against the expected project volume
3. To summarize the net regional economic benefit experienced through the recent staging of wind turbine generators (WTG) for Dominion Energy's 'Coast of Virginia Offshore Wind' (CVOSW) Pilot Project in Halifax Harbor in 2020
4. To describe realistic scenarios defining what percentage of the US offshore wind construction demand would be serviced utilizing the proposed Sheet Harbor base
5. To provide, for each scenario produced by 'Objective 4', a realistic prediction of the regional economic benefits that would result by virtue of an Offshore Wind supply base at Sheet Harbor.

Further to these main study objectives, WESI proposed to deliver material from a Drone Survey of the facilities at Sheet Harbor to be used for future marketing, engineering, and planning purposes.

Although there are many factors and variables that will influence the direction developers will take for offshore wind farm construction, the focus area of this study was limited to two main determining factors, specifically, the capability and capacity of available US ports and vessels. From a geographical perspective, OSW activities from Virginia to Massachusetts were the focus considering proximity to the Port of Sheet Harbor.

WESI employed a core team of project engineers and economic specialist for research, analysis and reporting who were supported by other internal support staff and external sources.

The team accessed a long list of online sources, existing reports, and studies to achieve the objectives outlined. A combination of sources allowed for an accurate picture of the OSW industry in the northeastern US to be built. In summary, across 8 states, 22 projects were identified that have reached the "planning" phase at a minimum. In accordance with the US DOE classification system, planning defines a project where a developer or regulatory agency has initiated the formal site control process. Project stages that follow "planning" are:

- Site Control
- Permitting
- Approved
- Financial Close

- Under Construction
- Operating
- Decommissioned
- On Hold/Cancelled

By removing the power contribution of the two operating projects (Block Island and the Virginia Pilot Project), the study concluded the northeastern US is with 19.5 GW of offshore wind projects in the "pipeline" from planning and beyond. In combination, these projects were determined to account for an offshore WTG total to be installed within the next decade of approximately 1700 units. Project research made it clear that 8 MW will be the minimum WTG size that will be installed for these future farms and, as time goes on, that size will increase. As each of the 1700 units will be comprised of large main components (i.e., foundations (1), transitions (1), towers (1-2 pieces), nacelles (1) and blades (3)), this data suggests a significant pending strain on US port infrastructure. In other words, US port availability will not meet demand thus presenting opportunity for suitably configured Atlantic Canada ports such as Sheet Harbor.

To test the above conclusion, a comprehensive review of announced or likely US ports for offshore wind construction was performed. The analysis, which focused primarily on available staging area, suggested that the northeastern US will gradually (between 2021 and 2028), reach a combined WTG staging capacity of 522 total units at a given time. However, as the analysis shows, port readiness dates and other factors indicate the US will struggle to provide staging support for early US projects. While port enhancements are ongoing, components will begin to arrive in the US from Europe. Based on announced project schedules, the window of time of peak US deficiency in this area, translating into opportunities for nearby Canadian ports such as the POSH, is 2023 – 2026. With many projects still at early stages of planning and US government approvals still pending, it may be expected that this window will shift or, more likely, extend beyond 2026.

This study process aimed also to gain an understanding of the adequacy of the US vessel fleet against expected demand in the same way ports were evaluated. This aspect of the research was performed in consideration of the complicating factors introduced to the use of foreign vessels by 'The Jones Act'. Also known as The Merchant Marine Act of 1920, the Jones Act is a United States federal statute that provides for the promotion and maintenance of the American merchant marine. Among other purposes, the law regulates maritime commerce in U.S. waters and between U.S. ports. Section 27 of the Merchant Marine Act deals with cabotage (coastwise trade) and requires that all goods transported by water between U.S. ports be carried on U.S.-flag ships, constructed in the United States, owned by U.S. citizens, and crewed by U.S. citizens and U.S. permanent residents.

Because offshore wind farms are considered US ports, wind developers interpret the Jones Act to mean they cannot use the typical (European) approach of running a wind turbine installation vessel (WTIV) back and forth between the staging port and the offshore construction site to complete WTG installation. Considering this, US developers have to date assumed foreign installation vessels will have to stay in field while US, "Jones Compliant" feeder vessels bring WTG main components to them from shore. Presently there are no US WTIVs in existence to provide developers with another option, but this is changing. The Dominion Energy WTIV "Charybdis" is under construction and will be ready in late 2023 at the earliest for the large, Dominion Virginia Power Project set to begin construction shortly after the vessel's completion. In addition, it appears there are no existing feeder vessels in the US with the preferred specifications to efficiently support large scale, serialized, OSW farm installation projects. A 'Super-Feeder' concept has been designed by 2nd Wind Marine with the ambition of filling the market gap but, with shipyard construction contracts not yet signed, the first of these vessels will not be available until 2024 at the earliest.

The attractiveness of the POSH (plus other suitable Canadian ports) to developers and installers is that a foreign WTIV can freely transit to and from the OSW construction locations. This same foreign WTIV cannot freely transit within the USA due to the Jones Act. In many cases, this is a more cost effective and lower risk alternative to the use of multiple feeder vessels and floating barges. Multiple feeder vessels and barges result in increased daily spread cost (e.g., fuel, equipment, personnel) and non-productive time (NPT) which are detrimental to project economics. This is the value proposition offered by POSH, or other suitable Canadian ports.

The results of the US port assessment, vessel fleet and Vineyard Wind case study project make a strong argument for the use of the POSH for OSW projects. To estimate economic impact for the region around Sheet Harbor and Nova Scotia, data acquired from the CVOSW Pilot Project experience at Halifax (objective 3) has been analyzed. With information provided from sources such as Holmes Maritime Inc., a high level summary of services and the associated total value for local businesses was acquired. In short, approximately 33 local companies were involved in the relatively small scope comprised mainly of vessel to vessel component transfers, preparations, and sea fastening. An estimated $4.27 MM USD was contributed to the regional economy as a result. Based on the known total capital cost (CAPEX) of the CVOSW Project ($300 MM USD), it has been inferred that the region realized an economic contribution of 1.42% of the project's total capital investment for its part in the vessel to vessel staging activities. For use in the prediction of future outcomes, this 1.42% is considered conservative for two reasons:

1. As an early pilot project with unique funding, investment and rate payer arrangements, the capital cost of the CVOSW project is regarded in the industry as being far greater than standard $USD/kW predictions. As future projects are executed, their cost per kW will reduce. This means the 1.42% would tend to increase as a percentage of overall CAPEX on upcoming projects with a larger number of turbines.
2. For CVOSW the tax implications of landing components on the quay at Halifax prevented use of additional onshore equipment and services. This hindered economic impact meaning there was potential for greater than $4.27 MM USD. At Sheet Harbor, quayside areas are bonded and as such, there are reduced tax implications. This will likely enable expanded services. Thus, the scale and variety of activity and services for any staging work at the POSH is expected to far exceed those performed for the CVOSW Pilot Project.

Most OSW projects currently proposed are larger in scale than a facility such as the POSH can support within a single construction year or, possibly two. As such, predictions of the economic benefits require assumption/calculation of the annual activity to be factored, in aggregate, with the conclusions above based on the CVOSW project experience. To achieve this, reference information from Eastpoint Engineering's assessment of the Sheet Harbor site was consulted to establish the 30 WTG (total unit) maximum storage capacity at the site. Using a figure of 8.9 days per WTG average installation time produced by the Vineyard Wind case analysis and, an installation season of assumed length of 210 days, an annual throughput of 23 WTGs is estimated for the site. Combining these numbers concludes a 53 WTG maximum annual storage/staging (activity) quantity at Sheet Harbor. To maintain a realistic analysis, lower percentages of this maximum have been arbitrarily assumed in the revenue predictions which are, 47% and 9.5% or maximum or, 25 and 5 total WTG units, respectively.

The final variable required for future economic impact predictions is the $USD/kW CAPEX cost likely to be achieved by the subject projects. This value was researched extensively and, the range was selected as $3000 USD/kW minimum to a $4500 USD/kW maximum. Although there is evidence to suggest early projects in the US will be even more costly than this, $4500 USD/kW has been used as the upper limit in the revenue calculations.

The figures above and acquired project information were combined to assess a range of revenue predictions for the POSH. In summary, the three main scenarios that are each with a range of outputs, are:

I. $3.0 MM USD investment in the POSH in 2021-2022 for predicted revenue from three projects (Vineyard Wind, Mayflower Wind and Park City Wind) from 2023 – 2025
II. $20.0 MM USD investment in the POSH in 2021-2023 for predicted revenue from eight projects (Vineyard, Revolution, Bay State, Mayflower, Sunrise, Park City, Liberty and Beacon) from 2023 – 2030
III. $35.0 MM USD investment in the POSH in 2021-2023 for predicted revenue from eight projects (Vineyard, Revolution, Bay State, Mayflower, Sunrise, Park City, Liberty and Beacon) from 2023 – 2030

The results of the revenue predictions and the associated ROI are as follows:

SCENARIO I – Average ROI of **812%** - **Profitable**
SCENARIO II – Average ROI of **195%** - **Profitable**
SCENARIO III – Average ROI of **84%** - **NOT Profitable**

The analysis results indicate there is a limit to the expenditure on site enhancement that is no longer profitable. However, for reasons explained above, these results may be considered conservative. Furthermore, the revenue and ROI calculations are limited to activity up to and including 2030. Activity beyond 2030, which is a real possibility if the port becomes established in this industry during the 2020's, will improve these ROI results.

Also to be considered in the interpretation of these results are ancillary port activities crucial to wind farm construction that are beyond the work associated with the WTGs. Although not analyzed in detail within the scope of this report, potential opportunities related to subsea cable staging, preparation and installation, rock storage and dumping for subsea scour protection, and other general services are flagged. These areas require further study in the context of the POSH.

There is growing consensus 2021 is the onset of a large and long term rush of construction activity in the US OSW industry. With investment, marketing, and eventual commitment from developers and /or other service providers, the POSH is evidently well positioned to contribute and realize the benefits this industry will bring. The information compiled in this report supports that opinion and, in many ways, provides justification of the site's advantages that may be brought to OSW developers and installers alike.

6. Objective 1 – OSW Industry in the Northeastern US

In 2008, the US Department of Energy (DOE) issued a report suggesting 20% of the country's electricity needs could be provided by wind power generation by the year 2030. With wind energy contributing just 1-2% at the time, the report, titled "20% Wind Energy by 2030", predicted rapid growth to achieve that target. In the area of focus for this study, the northeastern US, offshore wind will be a significant contributor to achieving the DOE targets given the large area of US territorial waters, generally higher mean wind speeds offshore and the coastal locations of many energy demand centers. In what the DOE has termed the "moderate growth scenario", the North Atlantic region of the US would have up to 20 offshore wind projects installed for a total power generating capacity of 10,000 MW (10 GW) by 2030. With only two offshore wind projects in the water as of 2021 for a total of just 42 MW, the US is, for several reasons, behind the pace of the moderate growth scenario. However, as this study and the information to follow supports, the pace is set to increase such that the moderate growth scenario targets or higher may be achieved. The recently elected Biden administration has vowed to double US offshore wind production by 2030 to support national renewable energy targets. Since taking power in January of 2021, the Biden administration has already accelerated the completion of the environmental analysis of the 800 MW Vineyard Wind Project off the coast of Massachusetts with speculations of a project approval this year. In contrast to the delays imposed by the previous presidential administration, the recent actions of President Biden suggest that the long stagnant offshore wind project pipeline in the US is set to begin moving forward in the very near future. The data assembled in this study does not only support this line of thinking, but also quantifies the growth potential for the states including Virginia and northward. Table 1 lists the amount of offshore wind power individual northeastern states have committed to by formal announcement and/or by policy and legislation between now and 2035, totaling at approximately 31.28 GW. In further support of the pending growth, 6.476 GW of agreed power purchases have been announced between these states and offshore wind farm developers for future projects, the majority of which that have not even been fully approved.

State	Target (MW) to 2035	Purchased or with Offtake Agreement (MW) as of 2021	Operating (MW) as of 2021	Developing & Operating Projects (MW)	Comments
Maine	3200	**12**	**0**	12	***Aqua Ventus Floating Pilot***
Mass.	5600	**1604**	**0**	6241	
Rhode Island	1000	**1234**	**30**	730	***Includes Block Island***
Connecticut	2000	**300**	**0**	804	
New York	9000	**1826**	**0**	3086	
New Jersey	7500	**1100**	**0**	4177	
Delaware			**0**	800	
Maryland	480	**388**	**0**	986	
Virginia	2500	**12**	**12**	2652	***Includes CVOW Pilot Project***
TOTALS (MW)	**31280**	**6476**	**42**	**19488**	

Table 1 - Offshore Wind Commitments and Developments in the Northeastern US

To assess the potential economic impact this data suggests for the Port of Sheet Harbor, an in depth analysis of the "Developing" Projects (fifth column in Table 1) has been performed. The pipeline totals reflect actual projects that are at various stages of development (stages as explained in section 6.1 below). The total of 19,488 MW includes all ongoing projects including the two operating (42 MW). The agreed power to be purchased will come from a selection of these pipeline projects. As such, subtracting the operating and purchased power totals from the 19,488 MW gives the total capacity of projects in development but *without* offtake agreements yet in place (12,970 MW). The following analysis will take for granted that this balance of 12,970 MW will be agreed for purchase at some point in the next decade. Given the direction of the current US Federal Government and the fact that the state totals committed now greatly exceed the current developing project pipeline, this is considered a reasonable assumption but not one upon which this study rests completely. Figure 1 below presents these quantities with more clarity.

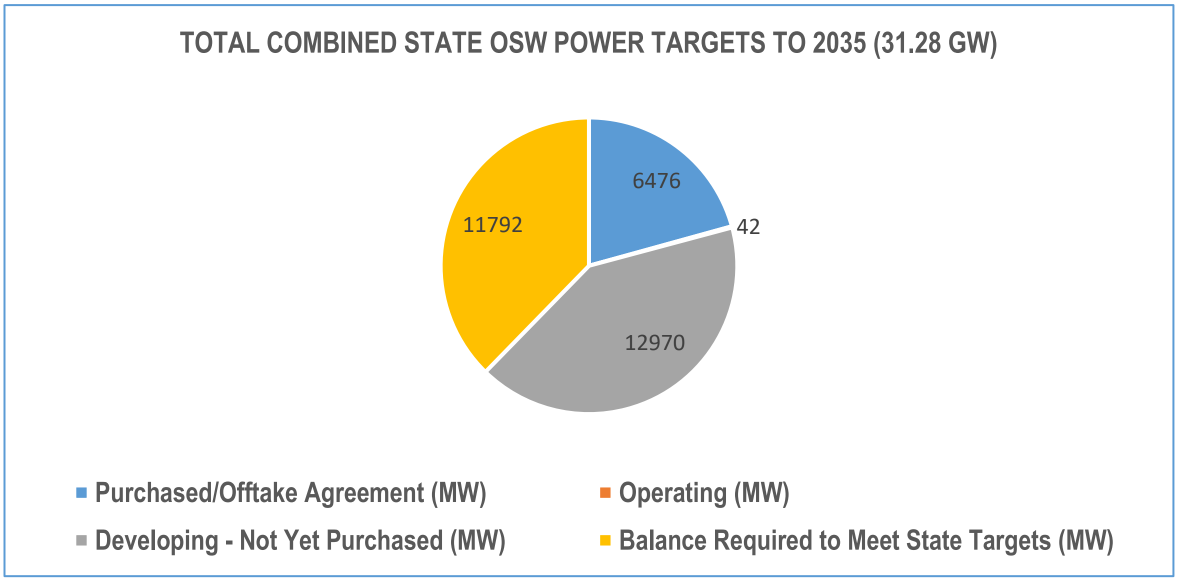


Figure 1 – Summary of Offshore Wind Commitments and Developments in the Northeastern US (Table 1)

This chart suggests that a 60% increase in developing OSW power is required to meet state targets. This increase will come by way of a combination of new projects proposed / announced within existing lease areas and, those that will be planned on leases yet to be obtained. The work of this report focuses only on the announced projects that are, at a minimum, at the planning stage wherein site control of a lease has been initiated. Any new projects that reach that stage, additional to those presented in this report, will increase the potential opportunity for POSH beyond what this study concludes.

6.1. US OSW Project Life-Cycle

The authority for the US federal waters in which offshore wind projects will be built is the US Bureau of Ocean Energy Management (BOEM). In a process like those in other parts of the world and for other industries (i.e., Oil and Gas); BOEM will periodically call for bids on offshore lease areas and developers will submit bid commitments to develop. As of the writing of this report, there are 16 active federal leases and 2 state leases in the northeastern US totaling 22 different projects all at different stages of development. Table 2 provides a summary of OSW project life cycle stages as classified by the US Department of Energy.

Step	Phase Name	Start Criteria	End Criteria
1	Planning	Starts when a developer or regulatory agency initiates the formal site control process	Ends when a developer obtains control of a site (e.g., through competitive auction or a determination of no competitive interest in an unsolicited lease area [United States only])
2	Site Control	Begins when a developer obtains site control (e.g., a lease or other contract)	Ends when the developer files major permit applications (e.g., a construction and operations plan for projects in the United States) or obtains an offtake agreement
3	Permitting = Site Control + Offtake Pathway	Starts when the developer files major permit applications (e.g., construction and operations plan or obtains an offtake agreement for electricity production)	Ends when regulatory entities authorize the project to proceed with construction and certify its offtake agreement
4	Approved	Starts when a project receives regulatory approval for construction activities and its offtake agreement	Ends when sponsor announces a "financial investment decision" and has signed contracts for construction work packages
5	Financial Close	Begins when sponsor announces a financial investment decision and has signed contracts for major construction work packages	Ends when project begins major construction work
6	Under Construction	Starts when offshore construction is initiated[11]	Ends when all turbines have been installed and the project is connected to and generating power for a land-based electrical grid
7	Operating	Commences when all turbines are installed and transmitting power to the grid; COD marks the official transition from construction to operation	Ends when the project has begun a formal process to decommission and stops feeding power to the grid
8	Decommissioned	Starts when the project has begun the formal process to decommission and stops transmitting power to the grid	Ends when the site has been fully restored and lease payments are no longer being made
9	On Hold/Cancelled	Starts if a sponsor stops development activities, discontinues lease payments, or abandons a prospective site	Ends when a sponsor restarts project development activity

Table 2 - US DOE Offshore Wind Project Phases

6.2. Current Offshore Wind Projects in the Northeastern US

Of the projects subject to analysis in this report, there are two "Operating", ten under "Site Control" and ten at the "Permitting" phase. A map of BOEM lease areas and pipeline projects for the northeastern US is provided in Figure 2.

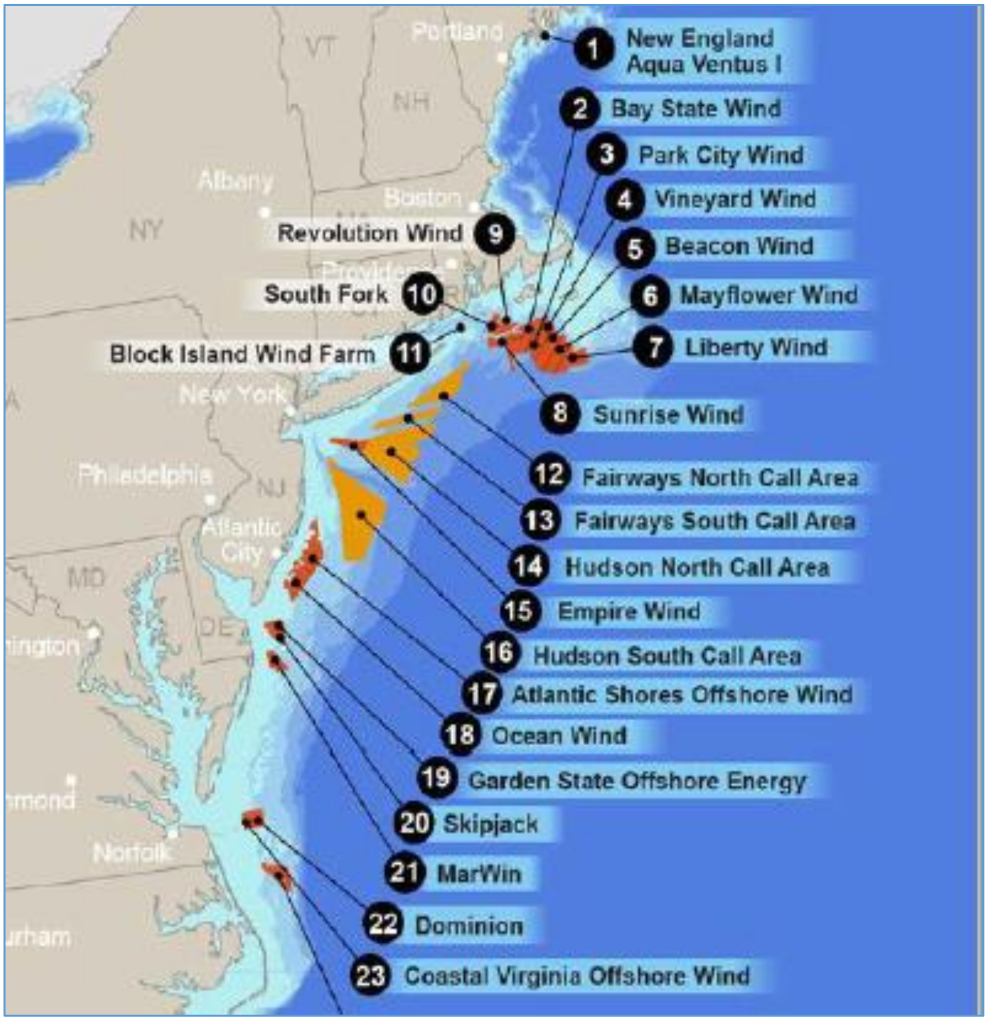


Figure 2 - US BOEM Offshore Wind Lease Areas

Active leases and developing projects that make up the 19,488 MW pipeline are shown as red areas in figure 2 while *future* call areas are orange. The four large future call areas (Hudson North, Hudson South, Fairways North and Fairways South) also known as the 'New York Bight' are expected to be auctioned in Q4 2021. The New York Bight comprises a total area of 7021 square km which, using the DOE estimation figure of 3 MW potential wind resource per square km of the offshore, may increase the regional pipeline by an additional 21,000 MW once leased. These figures suggest a potential doubling of the current regional industry plan. While it may be overly optimistic to include these areas in an analysis of near, to mid-term opportunities, the announced state targets suggest it is only a matter of time before at least a portion of these areas are developed. As explained above in this section, the construction volume analysis that will be presented in this report does not include the additional construction potential of the New York Bight.

Summary information of the developing regional pipeline projects was assembled through various sources and references such to support an analysis of future offshore construction volume. This information is provided in Table 3 with projects listed from nearest to furthest planned or expected commercial operation date.

Project / Company / Lease Holder	Developers and other Primary Participants	Commercial Operation Date	Status	Planned or Potential Project Size (MW)	Approx. WTG Size (MW)	Approx. WTG Quantity
DMME - CVOSW Project	Dominion Energy	**2020**	5-Operating	12	6	**2**
Deepwater Wind South Fork	Orsted/Eversource	**2023**	3-Permitting	130	8	**17**
Vineyard Wind 1	Avangrid/CIP	**2024**	3-Permitting	800	12	**67**
DWW Rev I, LCC (Revolution Wind)	Orsted/Eversource	**2024**	3-Permitting	700	8	**88**
Empire Wind 1	Equinor	**2024**	3-Permitting	816	10 - 15	**70**
Garden State Offshore Energy	Orsted	**2024**	2-Site Control	680	12	**57**
MarWin	US Wind Inc.	**2024**	3-Permitting	268	9	**32**
Block Island	Orsted/Eversource	**2016**	5-Operating	30	6	**5**
Bay State Wind	Orsted/Eversource	**2025**	2-Site Control	1360	8 - 14	**136**
Mayflower Wind Energy	EDPR/Shell	**2025**	3-Permitting	804	10	**80**
Sunrise Wind	Orsted/Eversource	**2025**	3-Permitting	880	8	**110**
Ocean Wind	Orsted	**2025**	3-Permitting	1100	12	**92**
Skipjack Offshore Energy	Orsted	**2025**	3-Permitting	120	12	**10**
Liberty Wind (Vineyard)	Avangrid/CIP	**2026**	2-Site Control	1300	12	**110**
Park City Wind (Vineyard Wind 2)	Avangrid/CIP	**2026**	3-Permitting	804	12	**67**
Empire Wind 2	Equinor	**2026**	2-Site Control	1260	10 - 15	**100**
Dominion Virginia Power (Virginia Electric and Power Company)	Dominion Energy	**2026**	2-Site Control	2640	13	**180**
Beacon Wind	Equinor	**2027**	2-Site Control	1230	12	**103**
Atlantic Shores Offshore Wind	EDF /Shell	**2027**	2-Site Control	2230	15	**150**
Ocean Wind 2	Orsted	**2029**	2-Site Control	847	12	**71**
MarWin 2	US Wind Inc.	**2029**	2-Site Control	718	9	**83**
Mayflower Wind Residual	EDPR/Shell	**2030**	2-Site Control	747	10	**75**
TOTALS				**19476**		**1705**

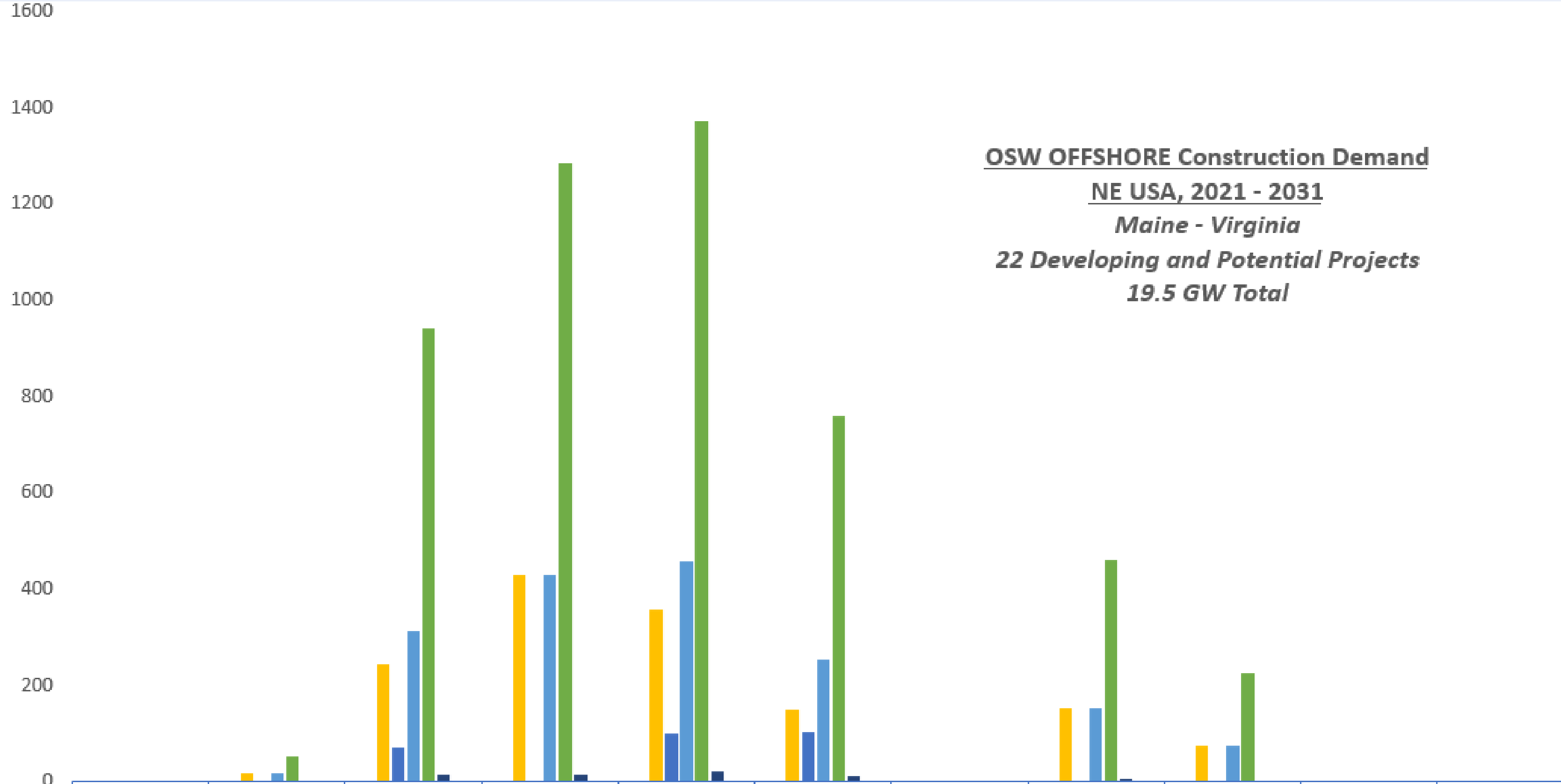
Table 3 - Developing OSW Projects in the Northeastern US

It is important to note that data in Table 3 may not be considered final and is subject to change. There is only a certain amount of technical information on these projects publicly available and, developers constantly alter plans based on further engineering and market conditions. Developers may adjust wind farm designs right up until construction. As an example, Vineyard Wind, which may be operational as soon as 2024 changed its turbine size in late 2020 from the 9.5 MW design submitted to BOEM in the Construction and Operations Plan (COP), to a 12 MW unit thus reducing their WTG quantity from (approximately) 80 to 67. As this report will show, the trend of increasing turbine sizes will amplify the strain on existing US infrastructure. This applies to ports, but more significantly to the US vessel fleet that will be required to transport components to the offshore wind fields. As turbine sizes increase, the selection of useful vessels decreases and as such, makes the option of working out of the POSH more attractive.

6.3. Construction Volume

The exact details of farm designs are kept confidential and are dynamic until a late stage. As such, the information provided in Table 3 is not meant to be exact but, offers a representation of pending construction volume in US OSW by year. Research into these projects confirms the obvious conclusion that as time progresses turbine sizes will be increasing. Except for Block Island and the CVOSW operating projects which both successfully installed 6 MW WTG units, available data suggests 8 MW will be the minimum size used in future OSW projects in the northeastern US. 10 and 12 MW units will be common in wind farm plans by mid to late in the decade. High level project data was used to forecast future OSW construction volume by WTG quantity per year as displayed in Figure 3.

In the following section, under Objective 2, the construction volume predicted in Figure 3 will be assessed against the available port capacity capable of supporting these projects in the northeastern region of the US. The results will show that the clear spike in construction activity from 2023 – 2026 may not be fully supported by the available US port infrastructure within the planned one to two year (per project) offshore construction time frame. This supports the prediction that developers will have an impetus, if not a need, to use the facility at Sheet Harbor.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Monopiles or Jacket (Quantity)		17	244	428	357	150		154	75		
GB Foundations (Quantity)		0	70	0	100	103		0	0		
Tower/Naecelle (Combined Unit Qty)		17	314	428	457	253		154	75		
Blades (Quantity)		51	942	1284	1371	759		462	225		
Substations (Quantity)		1	13	15	20	10		6	3		

Figure 3 - Offshore Wind Construction Demand Forecast, Northeastern US, 2021 – 2031

7. Objective 2 – Available US Support for Staging & Offshore Construction

The facilities, space, equipment, infrastructure, work force and other aspects required to support offshore wind farm construction are many. A comprehensive analysis of all aspects of the complete process are outside the scope of this study. As such, the research for this report has focused on two main aspects:

1) Port locations for storge, preparation and load-out of the main WTG components (i.e., foundations, transition pieces, towers, nacelles, and blades). In the OSW industry such locations are called **Staging Ports.** In the US, the term "marshalling" port is also used.

2) The vessels that load WTG components from the staging port, travel to the offshore wind farm location and install the WTG units (component by component). In this report, these vessels, typically called **Installation Vessels,** are subdivided into two categories:
   - **i)** Traditional (European Style) Wind Turbine Installation Vessels – **WTIVs**
   - **ii)** Vessels that support the installation process where WTIV's are restricted from accessing the staging port – **Feeder Vessels.**

For both 1 and 2, the objective stated simply was to ascertain whether the capacity required to meet future construction plans is or will be in place in the US. In each case, the intent of the assessments was not to produce a definitive conclusion but, to provide an output that would either support or challenge the potential for OSW staging activities at Sheet Harbor.

7.1. Port Requirements for OSW Staging

One of the ambitions of the offshore wind industry has always been, and continues to be, to minimize the effective cost of the power generated. This cost is referred to as the "Levelized Cost of Energy" (LCOE) which, typically goes down as turbine size increases. As the technology has evolved, these advancements have been realized and thus brought about substantial increases in the weight and size of WTG main components. In the range of turbine sizes planned for projects in the pipeline off the northeastern US, component sizes are such that the supporting infrastructure capable of handling, staging, on and offloading them is not abundant. In many cases, significant upgrades and investments are required at ports to make them OSW ready. During this analysis, OSW staging port criteria has been viewed in two tiers whereby "Tier 1" criteria are the basic arrangements at a port or quay that require significant investment to upgrade (if they can be upgraded at all) i.e., available acreage; while "Tier 2" criteria are enhancements that can be achieved with lesser investments (i.e., the addition of a quayside mobile crane). Table 4 provides a summary of main Tier 1 and Tier 2 characteristics.

OSW STAGING PORT CRITERIA	
TIER 1	**TIER 2**
Quayside Length	Onsite Work Force
Quayside Water Depth	Cranes
Approach Channel Depth	Modular Transporters (SPMTs)
Approach Channel Width	Other Equipment
Air Draft	Support shops and facilities
Seabed Strength at Quay	Proximity to services, highways and airports
Quayside and Laydown Area Strength	Accommodations
Available Area with Required Strength	Fuel, water, etc.

Table 4 - Offshore Wind Staging Port Criteria

7.2. Port Capacity in the NE US

In performing a high level assessment of available US port capacity, only Tier 1 criteria were considered. In particular, the focus was the available area. This approach assumed that any port that had been identified, announced, contracted, or invested in by developers or others to support offshore wind staging will already or, by virtue of the investments proposed, eventually have, most of the Tier 1 criteria satisfied for a range of vessels and turbine sizes (WESI's subsequent review of the specifications collected for the selected ports supports this assumption). Accordingly, the analysis moves forward on the premise that the available area with the required bearing strength is the single most important factor in determining what WTG unit volume a given port may support at a time during the construction phase. 1.5 acres per WTG unit was used as the approximate space requirement for staging a 10 MW WTG set complete (i.e., all main components including foundations) for installation in 30 m of water. The number was obtained by extrapolation of data provided in the 2014 report provided to the DOE by GL Garrad Hassan titled "Assessment of Ports for Offshore Wind Development in the United States". WESI conducted a market assessment to verify this key metric (1.5A/WTG). Our review concluded the number was accurate and in fact small compared to estimates used by other projects around the globe. Despite this feedback it was decided not to increase the estimate as the use of a smaller number (i.e., 1.5 acres instead of 2 acres) would mean an over estimation of US port staging capacity and thus produce a conservative result of the overflow demand for sites outside of the country such as Sheet Harbor.

By extensive research, review of existing studies and reports, news articles and consultation with ORECA, a list of 14 main US staging ports from Virginia to Massachusetts was developed. These ports are those that have been identified firmly or potentially as bases of operation for the staging of one or multiple future OSW projects. For these selections, "identified" means signed agreements and/or confirmed investments by developers, governments and other parties are in place or, the ports have been otherwise named or announced in the media as a support terminal for an offshore wind project in the region. These ports, and sheet harbor are listed in Table 5 along with respective air drafts, available area, calculated WTG staging capacity and approximate ready dates.

Port Location	Overhead Restrictions (m)	Marshalling Area (acres)	Upgraded Total WTG Capacity	Date Ready
POSH (Nova Scotia)	none	47	**30.00**	
NBMCT (Mass.)	none	21	**14.00**	2021
Brayton Point Commerce Center (Mass)	**41**	48.3	**32.20**	2021
ProvPort (RI)	**59**	20	**13.33**	2021
Quonset, Port of Davisville (RI)	**59**	60	**40.00**	2021
New London State Pier (CT)	none	25	**16.67**	2022
Bridgeport (CT)	none	18.3	**12.20**	2023
SBMT (NY)	**60.3**	64	**42.67**	2024
Port of Albany (NY)	**40.87**	77	**51.33**	2024
Port of Coeymans (GBS) (NY)	**40.8**	125	**83.33**	2023
Paulsboro (NJ)	**53**	103	**68.67**	2023
Salem, Hope Creek (NJ) - New Jersey Wind Port	none	30	**20.00**	2023
Dundalk Marine Terminal (MD)	**56.4**	100	**66.67**	2028
Sparrows Point Shipyard Industrial Complex (MD) - Trade Point Atl.	**56.4**	50	**33.33**	2021
Portsmouth Marine Terminal (VA)	none	42	**28.00**	2025

Table 5 – Main US OSW Staging Ports

Note that 5 of 14 US ports have no air draft restrictions which will limit the size of jack-up vessels that can access the quayside. POSH also has no air draft restriction. Air draft will be discussed in greater detail in the following sections on vessels and the project specific value case review.

By combining the results of Figure 3 (expected construction volume) and Table 5 (US Port Capacity) a very basic, high level assessment of the adequacy of US port infrastructure is obtained. The assessment result considers key assumptions and disregards certain realities such that the results serve to **underestimate** opportunities for the POSH.

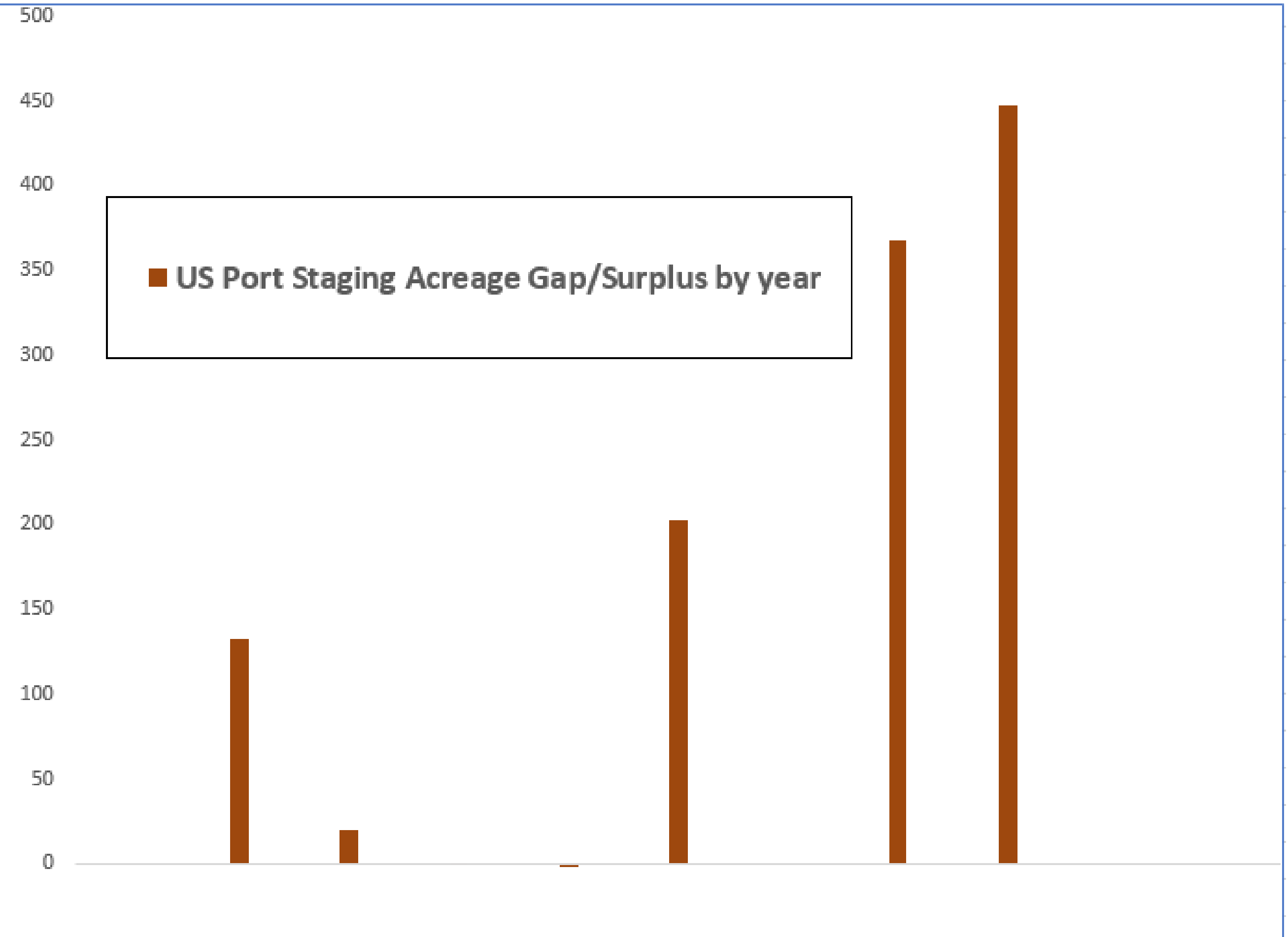
Assumptions and considerations are as follows:

1. All 14 NE US ports listed could be available to all projects. Due to contractual and lease requirements, this is not likely. As such, individual projects may see increased WTG unit overflow beyond what this comparison establishes.
2. No conflict with schedule and space requirements of other industries and projects which may also be serviced by some of these ports.
3. Air draft restrictions, which will reduce the numbers of ports suitable for use (9 of 14 ports have air draft restrictions), are not considered in this analysis.
4. Required US vessels (Jones Act Compliant) to support the projects are available. If they are not, US ports will see lower utilization. This is discussed more in further sections.

5. This space demand assessment does not include the area requirements of export and array cable staging and offshore substations of which there are a forecasted 68 to be staged and installed offshore across the decade, each with large top side and foundation components[1].
6. Construction volume is not including future projects in the New York Bight call areas. As these areas are expected to be auctioned by the end of this year the construction volume analyzed in this report may increase substantially in the next 1 – 2 years. Based on area alone, the New York Bight has the potential to double the current project pipeline.
7. Storge requirements in the US will exceed those typically experienced in EU wind farm construction. In the EU, components are manufactured near the staging ports. In the case of the US projects, WTG component deliveries will be coming from the EU. So, the quantity of units stored needs to be high (compared to traditional EU projects) to allow for the risk of delays for shipments coming across the Atlantic. According to ORECA, for the larger wind farms in Europe (100 units+), the ambition would be for a staging port to contain around 30-40 total units. In the US, an ability to store more than this number will account for, and mitigate against, potential delays with incoming shipments and allow for the option to run simultaneous WTIVs (pending quayside availability).

For these reasons, the result, as presented in Figure 4 below, may be considered realistic if not conservative. This information provides an indication that, during peak construction years before US port infrastructure is fully developed, there is a period during which US OSW developers will struggle to find space in the US to store and stage WTG components.

[1] The research and analysis of projects that provided the information in sections 6.2 and 6.3 above also provided approximate quantities of offshore substations that would be required for each. The construction volume of those components is not included in the analysis of these sections (i.e., Figure 3).



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
US Port Staging Acreage Gap/Surplus by year		132.5	19.7	-0.6	-1.6	202.4		368.1	447.1		

Figure 4 - Forecasted US Staging Acreage Gap/Surplus by year (WTG Total Units)

Based on current information, the chart in Figure 4 suggests there is likely to be a window of opportunity for Canadian ports in 2023 – 2025 at a minimum. Changes in installation schedule and approaches may shift this window by one to two years. Regardless, other factors, as will be discussed in this report, and the addition of new projects from future lease calls (New York Bight areas) could potentially see the window, and thus opportunity for the POSH, extended. In any case, the output of Figure 4 is in consideration of port space only, the following sections will describe other reasons why the POSH is an attractive option for the industry which are unrelated to available US staging acreage.

7.3. Vessels

As with ports, there are criteria unique to OSW installation activities that apply to vessels that were assessed in this study. These criteria and a review of the available US fleet that meet the criteria are discussed further below. Key to understanding the importance of the availability of US vessels with the required capabilities, are the complicating factors of port access enforced by 'The Jones Act'.

7.4. Jones Act and Other Port Access Limitations

In the introduction section of this report, the Jones Act is mentioned in the context of the limitations it imposes on the use of specialized foreign vessels for OSW projects in the US. Also known as The Merchant Marine Act of 1920, it is a United States federal statute that provides for the promotion and maintenance of the American merchant marine. Among other purposes, the law regulates maritime commerce in U.S. waters and between U.S. ports. Section 27 of the Merchant Marine Act is known as the Jones Act and deals with cabotage (coastwise trade) and requires that all goods transported by water between U.S. ports be carried on U.S.-flag ships, constructed in the United States, owned by U.S. citizens, and crewed by U.S. citizens and U.S. permanent residents. The body that interprets and makes rulings associated with this act, US Customs and Border Protection (CBP), generally considers an offshore wind farm in US waters to be a port, thus making construction activity between ports and project sites using foreign vessels a violation of the act. There is some history of case specific exemptions to the Jones Act but, for large quantity serialized offshore installation of WTGs, developers are not optimistic such exemptions for foreign OSW project WTIVs are likely.

Continuation of the Jones Act without exemptions - would possibly increase activity in Canadian ports such as POSH.

Regardless of the Jones Act, OSW construction projects in the northeastern US will experience port access challenges associated with the vessel limitations imposed by the Tier 1 port criteria discussed above. If the feeder vessel model of Block Island is to be replicated on upcoming projects, and foreign WTIVs remain in the field, the proposed turbine size range of 8 – 15 MW will mean high specification feeder vessels will be required to make installation from the US coast economical. Feeders will need the deck space, jacking, cargo, and height capability to be effective. As those specifications increase, the feeder vessels become more limited on ports they can access thus reducing available options within the US. To use jacking height as an example, in 50 m of water, assuming a jack-up feeder vessel requires legs 55 – 65 m in total length to effectively support a WTIV, 3 of the 14 ports listed above are not accessible. Due to the size required of future used feeder vessels to match WTG component sizes, similar restrictions on port access due to vessel *width* may also be expected. With these limitations considered, ports like Sheet Harbor with no air draft or approach width restrictions become attractive to OSW developers and vessel owners.

The following sections will attempt to assess the size of the US vessel fleet with the specifications required to support future OSW construction. Furthermore, this study will present a cost and schedule comparison between the US Feeder model and the European, single WTIV model running from sheet harbor. And, given the limited availability of Jones Act compliant jack-up feeder vessels (as is evident in section 7.10 below), the floating barge feeder vessel case will also be presented. For reasons explained in section 7.6 below, the Vineyard Wind project has been chosen as the study project for these cases.

7.5. WTIVs – Global and in the US

Currently, there are no US built and flagged WTIVs operating however there is one currently being constructed – Dominion Energy's 'Charybdis' – expected delivery in 2023 at the earliest. Given the requirements of the Jones Act, this essentially means that until the arrival of the Charybdis, there is no WTIV available in the world able to service offshore wind farm construction in the US in the same way it has been traditionally done in Europe. This is referring to the process by which a WTIV shuttles back and forth between the staging port and the offshore installation site rotationally loading components and installing them. Dominion may have the Charybdis on the market for a short period to support US projects up until 2024 or 2025 when the vessel will begin a 2 – 4 year campaign serving as installation vessel for the 2640 MW Dominion Virginia Power project. The size of the upcoming Dominion Project is not the least of factors that have justified the three year, $500 Million USD investment for this vessel's construction. There are also unique investment, cost sharing and power purchase aspects of the Dominion Energy Virginia Power Project, which are beyond the scope of this report to explain, that have justified the vessel's construction. In general, investors have been hesitant to make the commitment required to bring more US WTIVs into the picture. There is speculation that with the support being shown by the Biden government, this hesitation may disappear soon. Following the final approval of Vineyard Wind, which is expected by the end of 2021, investors would see the approval of a large scale offshore wind farm is US waters as the security they need to move forward with more US WTIVs. Note that new vessel construction would take three or more years.

An increase in the availability of Jones Act compliant WTIVs would possibly reduce activity in Canadian ports such as POSH.

The current state of the US WTIV fleet and the Jones Act do not change the demand for these types of vessels for the future OSW construction industry in the US. Foreign WTIV's may still be integral to the process by way of the "feeder" vessel process. This concept, which will be analyzed in detail further in this report, was used for the 2016 installation of the 5 x 6 MW Block Island Project in Rhode Island. In short, Jones compliant feeder vessels ran components from shore and transferred them to a foreign WTIV offshore for installation. Although the WTIV was not Jones compliant, this arrangement was not considered to violate the act as the WTIV did no transport of cargo between US ports. Most, if not all US developers are considering a similar approach for upcoming projects and as such, will compete for their share of the global WTIV supply. With the forecasted global growth of offshore wind, this supply is seen currently to be limited with somewhere in the range of 40 WTIV or Heavy Lift Jack-up vessels with varying degrees of technical limitations available to support offshore wind construction around the world. For the 8MW minimum turbine size associated with the northeastern US projects, the selected installation vessel list will be much smaller, perhaps as low as 10 or less.

Figures 5 and 6, provided courtesy of a December 2020 report by the US Government Accountability Office (see references), demonstrate the difference in the two processes explained above.

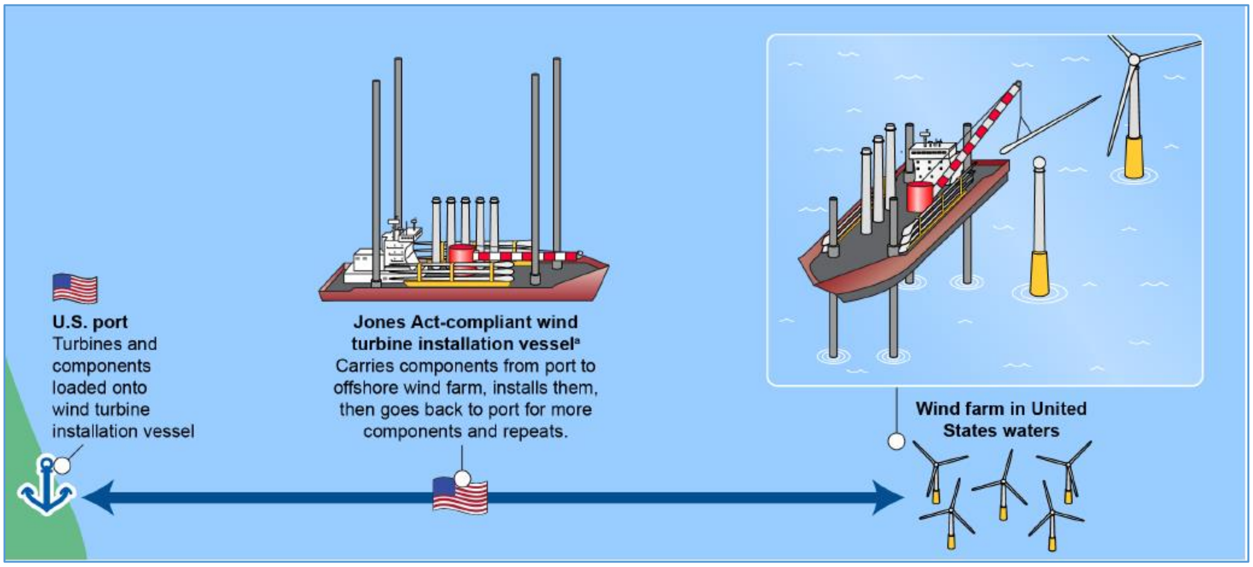


Figure 5 - Offshore Installation Using a Jones Act Compliant WTIV

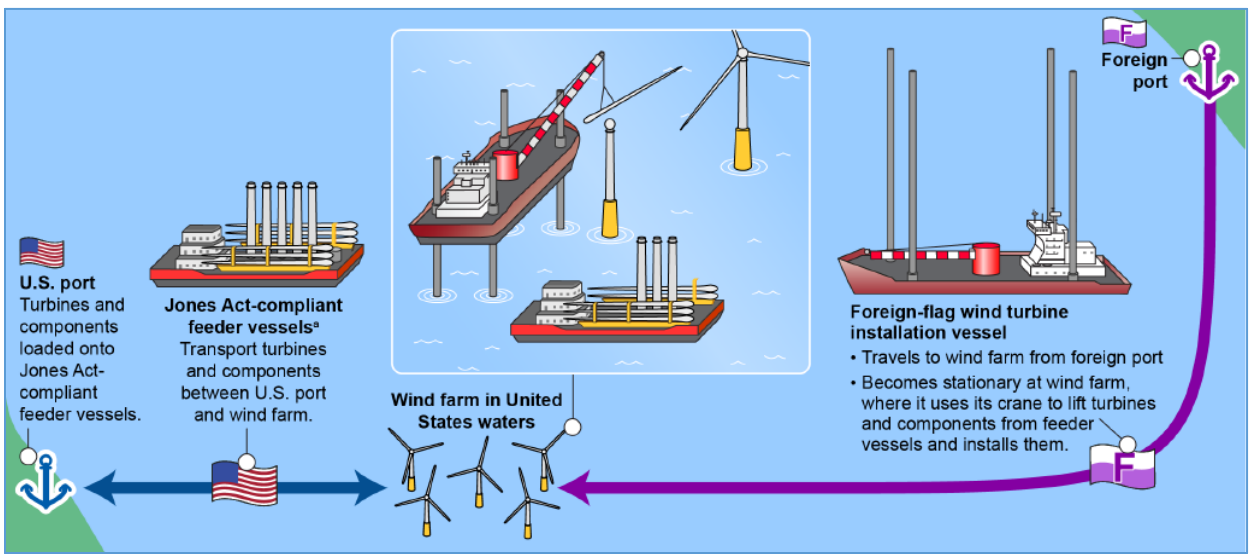


Figure 6 - Offshore Installation Using a Foreign WTIV and Jones Act Compliant Feeder Vessels

7.6. The Vineyard Wind Project Case Studies

Of the 22 projects presented previously in this report, there are 9 projects in a cluster with closest proximity to Canadian waters and the Port of Sheet Harbor. In selecting which project of these 9 was the best for a focused case study and value proposition for the use of sheet harbor, the following logic was applied:

- Projects smaller in size would not drive the same demand and economics of scale that will make the port of sheet harbor an attractive option for staging. As such, South Fork at 130 MW was eliminated.
- Projects very close to the US coastline were assumed not as likely to be supported by a Canadian port as the sheer magnitude of the distance-to-port differential may greatly impact the comparison. As further analysis

shows, this assumption may be challenged but in selecting a case study project, this line of thinking eliminated Revolution Wind, South Fork and Sunrise Wind.

- Given the near term construction demand gap, it was thought best to select a project that will undergo construction relatively soon and during the 2023 – 2025 demand peak as forecasted in figures 3 and 4 above. In line with this logic, Equinor's Beacon Wind was eliminated as construction is currently estimated to begin in 2026.
- Of the remaining five projects, Vineyard Wind 1 was chosen for the following reasons:
    - It is the project furthest along in the permitting process and closest to final approval.
    - **The COP submitted to the BOEM specifically mentions Sheet Harbor as a potential staging support location.**
    - Between WESI and ORECA, it is the project with the best access to contacts who would help guide and validate assumptions and analysis results.

The case study used the general project information presented in Table 6 below as constant for the different scenarios that were run for Vineyard Wind:

PROJECT	VINEYARD WIND R0
OPERATIONAL DATE	2024
DEVELOPER	Avangrid/CIP
PROJECT SIZE (MW)	800
CHOSEN & PROBABLE PORT(S)	NBMCT Brayton Point CC
TOTAL EQUIVALENT WTG CAPACITY AT CHOSEN & PROBABLE PORT(S)	46.2
PORT HEIGHT RESTRICTIONS (m)	NBMCT - NONE Brayton Point CC - 41
ASSUMED FEEDER VESSEL LENGTH (m)	100
ASSUMED FEEDER VESSEL BREADTH (m)	40
ASSUMED FEEDER VESSEL LEG HEIGHT (m)	70
ASSUMED FEEDER VESSEL CARGO & LIFT CAPACITY (tonne)	3500
FEEDER QTY	1 - 2
MEAN DISTANCE FROM PROJECT TO CHOSEN PORT(S) (km)	NBMCT - 73.92 Brayton Point CC - 94.2
PROJECT MEAN DISTANCE TO POSH (km)	784.77

Table 6 - General information for Vineyard Wind Project Case Study

27 scenarios were performed in three groups of nine. The three main groups, named 'Base Feeder Analysis', 'Jack-up Feeder Analysis' and 'Barge Floater Feeder Analysis' are different only in the incremental Non-Productive Time (NPT) factors applied, per feeder, on top of those of the WTIV. In summary:

- **Base Feeder Analysis:** add 5 – 10 % to total installation NPT for each feeder required.
- **Jack-Up Feeder Analysis:** add 15 – 20% to total installation NPT (equivalent to WTIV) for each feeder required.
- **Barge Floater Analysis:** add 35% to total installation NPT for each feeder required.

The definition of these three analysis groups is discussed further in section 7.7 and highlighted in table 7. The base feeder NPT was based on an initial assumption that was thought conservative (in favor of US ports), while the other two cases use NPT factors based on actual met ocean data acquired for the Vineyard Wind project location.

The nine scenarios run within each group defined above were labelled R1 – R9. These are described below along with the assumptions, information or constants adjusted in their respective comparative analyses. In all cases, the comparison in question was between using a WTIV only from POSH and, using the US base port with a foreign WTIV and US feeders.

- R1 – base case using a starting point of values from table 7 below reflecting initial assumptions for a jacket foundation. Initially, 15% WTIV NPT and 5% Incremental per feeder was used.
- R2 – increased per foundation load time at quayside from 6 to 8 hours as guided by OERCA for the jacket foundation case.
- R3 – WTIV capacity per trip changed from 6 "sets" (total foundations or total topsides) to 4 to better reflect current technical limitations of WTIV's for the 8 – 10 MW turbine size range.
- R4 – changed WTIV capacity back to 6. Also, changed WTIV offshore install time per foundation from 90 hours to 50 hours to reflect monopile activities (instead of jacket). Accordingly, quayside loadout time per foundation was also increased to 10 hours, again reflecting a better estimate of times for a monopile rather than a jacket. These time adjustments were also the result of thorough review held with ORECA.
- R5 – Maintained monopile case time estimates but changed per trip WTIV capacity back to 4 sets.
- R6 – Reiterate R3 but with WTIV NPT increased from 15 to 20%. In the base feeder case, incremental NPT was also increased from 5 to 10% for this scenario.
- R7 - Reiterate R5 but with WTIV NPT increased from 15 to 20%. In the base feeder case, incremental NPT was also increased from 5 to 10% for this scenario.
- R8 – Reiterate R6 but reduce total WTG quantity from 80 to 67.
- R9 – Reiterate R7 but reduce total WTG quantity from 80 to 67.

Table 7 provides a summary of the assumptions and variables adjusted for the nine scenarios for each of the three main groups.

	RANGE OF VALUES FOR ANALYSIS SCENARIOS		
VARIABLE DESCRIPTION	**BASE FEEDER**	**JACK-UP FEEDER(S)**	**BARGE FEEDER(S)**
Project WTG Quantity	67, 80	67, 80	67, 80
WTIV Quantity	1	1	1
Feeder Vessel Quantity	1, 2	1, 2	1, 2
WTIV Topsides Set Complete Installation Time (hrs. per WTG) ***Before Weather NPT*** ***Including Jack-up and Jack-down times (12 hrs. per)***	50	50	50
WTIV Foundation Set Complete Installation Time (hrs. per WTG) ***Before Weather NPT*** ***Including Jack-up and Jack-down times (12 hrs. per)*** ***Range applied for jacket vs. monopile***	50, 90	50, 90	50, 90
Topsides Set Load-out Time at Quay (hrs. per WTG) ***WTIV or Feeder***	12	12	12
Foundation Set Load-out Time at Quay (hrs. per WTG) ***WTIV or Feeder*** ***Range applied for jacket vs. monopile***	6, 8, 10	6, 8, 10	6, 8, 10
Onsite Transfer of Topside from Feeder to WTIV (hrs. per WTG)	27.5	27.5	27.5
Onsite Transfer of Foundation from Feeder to WTIV (hrs. per WTG) ***Number reflects jacket foundation***	49.5	49.5	49.5
Topside or Foundation sets transported by WTIV per trip (Qty.)	4, 6	4, 6	4, 6

WTIV Empty Voyage Speed (km/hr.)	22.22	22.22	22.22
WTIV Full Voyage Speed (km/hr.)	14.82	14.82	14.82
Feeder Empty Voyage Speed (km/hr.)	18.52	18.52	18.52
Feeder Full Voyage Speed (km/hr.)	11.11	11.11	11.11
WTIV Sea State NPT % Factor Applied (%)	15 - 20	15 - 20	15 - 20
Incremental Sea State NPT Factor Applied per Feeder (%)	5 - 10	15 - 20	35
WTIV Day Rate (USD)	$250,000	$250,000	$250,000
Feeder Vessel Day Rate (USD)	$90,000	$90,000	$90,000
Approximate WTIV Fuel cost per 24 hours based on $3.35 USD/gallon	$17,160	$17,160	$17,160
Approximate FEEDER Fuel cost per 24 hours based on $3.35 USD/gallon	$13,728	$13,728	$13,728

Table 7 - Assumptions and Variables of Vineyard Wind Project Case Study

7.7. Sea State and Non-Productive Time (NPT) Discussion

Before exploring the results of the analyses described, it is crucial to explain how the driving variable across the three sub cases, i.e., vessel NPT, was studied. To start with, wind is ignored. Because these cases assume feeder vessels are *without* their own cranes, all in-field lifting operations are to be done using the WTIV crane. Furthermore, the project installation assumptions made suggest many components may be installed directly from the feeder barge. For these reasons, any wind related NPT will be due to the restrictions of the WTIV onboard crane and as such will be constant across all cases and not impact the comparative analysis. As such, only sea states and the associated NPT resulting from them were considered.

WTIV NPT % was estimated and validated by sources at ORECA. Although the number is not data based, for this analysis, it is considered conservative and, as the same WTIV NPT multiplication factor is applied in the sheet harbor and US Feeder analysis cases, its magnitude impacts both equally and therefore is not a determining factor in these comparisons.

In the 'base feeder' analyses, additional NPT percentages per feeder vessel were arbitrarily selected as 5 and 10%. Again, these percentages are not data based but adding an increment much lower than the 15 and 20% NPT numbers used for the WTIV itself is considered conservative and in favor of the US feeder case[2].

To predict incremental feeder vessel NPT more accurately for the specific jack-up feeder and barge feeder cases, a file with 262968 data points of significant sea height (Hs) for the Vineyard Wind location spanning from 1990 – 2019 was acquired. WESI's source at ORECA was guided to this information by contacts with weather data specialist company, Lautec - https://esox.lautec.com/. Acquired data was filtered to remove all points for November – March thus leaving Hs data applicable to the established OSW installation season. The following sea state limitations were applied to assess the percentage of time each were exceeded. 2m Hs is a well-documented limitation for jacking operations with a WTIV. The analysis assumed it would be slightly lower for a smaller, feeder jack-up (1.5m). And in consultation with ORECA, 1.0 m Hs was chosen as the limit for sensitive, large component lifts from a floating barge feeder on location at on offshore wind farm. The results of this exercise are summarized in Table 8.

[2] The incremental nature of the NPT % figures added (i.e., added on top of the WTIV NPT %) was done so on the assumption and basic understanding that the sea state sensitive operations of a feeder vessel, which is during the in-field jack-up/transfer/jack-down phase of the installation cycle, are completely out of phase with the sea state sensitive operations (jacking up and down) of the WTIV. As such, the NPT would not be in parallel and therefore a numerical summation of NPT was the chosen approach to realistically define critical path time per WTG install. This approach is applied consistently across all analyses.

VINEYARD WIND AREA LIMITING SEA STATE PERCENTAGES		
WTIV	Hs > 2.0m	9%
Jacking Feeder	Hs > 1.5m	23%
Barge Feeder	Hs > 1.0m	59%

Table 8 - Vineyard Wind Area Limiting Sea State Percentages

For each of the three sub cases, the above percentages were applied against the respective percent of WTG installation cycle time that is sensitive to sea states. The percentage of cycle time for each sub case was calculated and the average of the nine scenarios for each was taken. In the jacking feeder case, in-field jack-down time was not included as it is typically not on the critical path of the installation. Taking this approach is again conservative and acts in favor of the US Feeder vessel case. In the case of the barge feeder, all time spent transferring components to the WTIV was considered sensitive to sea states as the vessels would be floating and not generally designed with favorable motion characteristics. These percentages and the resulting combined (overall) predicted sea state related NPT for each sub case based on the data acquired, is provided in Tables 9 and 10 below.

WTIV **Sea State Sensitive Ops IN FIELD** (% of turbine install cycle)	**JACKING FEEDER** **Sea State Sensitive Ops IN FIELD** (% of turbine install cycle)	**BARGE FEEDER** **Sea State Sensitive Ops IN FIELD** (% of turbine install cycle)
27%	**18%**	**57%**

Table 9 - Vineyard Wind Case Study Sea State Sensitive Operations (Average)

Overall Combined NPT - SEA STATE ONLY	
WTIV	3%
Jacking Feeder	4%
Barge Feeder	34%

Table 10 - Combined Average NPT for Vineyard Wind Case Study

The results of Table 10 provided the following conclusions to guide the final comparative analysis of each the jacking feeder and barge feeder cases against the WTIV working from Sheet Harbor:

1) Large jacking feeder vessels, on their own, may be considered to have very similar, if not the same sea state related NPT performance as does the WTIV itself. In this study, the previously assumed WTIV NPT numbers of 15 – 20% were not changed to match those shown in Table 10 because, as previously explained, the number is applied to both cases in the comparison and therefore does not impact the outcome. However, in the jacking feeder analysis case, these results provided the conclusion that in all cases, incremental NPT for each jacking feeder should be equal to the base WTIV NPT number used.

2) In support of popular opinion, non-jacking barges have the potential to introduce significant NPT to offshore transfer operations to the WTIV. The result of Table 10 was applied incrementally to the sea state NPT percentage in the barge feeder sub case for each vessel required.

The data, analysis, and conclusions above seem to support of what is commonly understood amongst those inside, or with interest in the future OSW industry in the northeastern US. This is to say that the use of US ports and the feeder vessel model will rely on the availability of large jack-up vessels to minimize the inefficiency and weather induced NPT associated with the feeder process if floating barges are used. The sections that follow will clarify this point in greater detail while also explaining how the current, and near term shortage of the US jack-up vessels required for these operations translate into further support of the business case for using Sheet Harbor as a staging and offshore construction base.

7.8. Vineyard Wind Case Study Results

Developers will vary in their approach to the offshore installation scope for their projects. However, it is relevant to note that regardless of the approach, i.e., whether the chosen approach is to do all foundations one year and topsides the next or, to use two installation vessels in a season and have foundations installed just ahead of topsides, the results of this analysis stand. Most, if not all, variable relationships that drive the economics of offshore wind farm installation are linear and as such, results may be broadly applied. For example, if an additional WTIV is employed, daily spread cost will double but project installation time may be cut in half. The conclusions of this analysis as presented below should be considered applicable regardless off the chosen installation process or sequence.

VINEYARD WIND 1 OFFSHORE WTG INSTALLATION CASE STUDY	RESULTING AVERAGE FROM 9 SCENARIOS (SEE TABLE 7)			
	WTIV BASED OUT OF POSH *(15 - 20% NPT)*	BASE FEEDER CASE *(5 - 10% NPT INCREMENT PER FEEDER)*	JACK-UP FEEDER CASE *(PER FEEDER NPT INCREMENT = WTIV)*	BARGE FEEDER CASE *(35% NPT INCREMENT PER FEEDER)*
DAYS PER WTG INSTALLATION *(INCLUDING FOUNDATION)*	**8.9**	**7.2**	**8**	**9.4**
TOTAL PROJECT WTG INSTALLATION TIME (DAYS) *(ASSUMING 67 WTG UNITS)*	**596.3**	**482.4**	**536**	**629.8**
TOTAL PROJECT WTG INSTALLATION COST (MM USD)	**$183.03**	**$228.75**	**$254.78**	**$301.09**

Table 11 - Vineyard Wind Case Study Results (Average)

Table 11 provides the average outputs of the Vineyard Wind Project installation comparison case study. While the data provides several clear conclusions, it also leaves room for discussion and possibly, further analyses.

In all cases, working a single WTIV from Sheet Harbor is the least costly offshore installation option. This is no surprise as without the additional vessels and fuel costs in the picture, daily spread rate during the installation is much lower.

The results for total installation time are less straight forward and as such are discussed in more detail below. However, there is a key point to consider in fully understanding the potential advantage of using the POSH. To allow for a like for like comparison, the above analysis was performed for the April – October installation season which is a safe window primarily driven by the feeder vessels. According to ORECA, using a WTIV only from the POSH could in fact allow installation to continue throughout the winter months as is done in Europe. Although the results of this study present the benefit of Sheet Harbor without that fact considered, it should be noted that such an adjustment to the analysis would skew results even further in its favor.

7.9. POSH vs. Base Feeder Case

The results of the 'Base Feeder' analysis are to be taken with the understanding that the 5 – 10% incremental NPT number was arbitrarily selected. As the Lautec data and subsequent analyses suggest, a best case for the incremental

NPT of a feeder vessel would be equal to that of the WTIV, not significantly less. As such, this base feeder case is not considered realistic.

Furthermore, the difference in total installation cost is of a magnitude that cannot be ignored. Although the consensus is that a developer would take installation time saved over money, the following points relevant to the value proposition are presented:

- The offshore installation season from April – October is approximately 210 days. With the total installation times predicted in table 11, both the POSH and Base Feeder Case options have installation progressing into a third season. There is benefit to developers to save a season but, once vessels are mobilized and activities begin *within* a season, there may not be much value added whether work is completed early or late that same installation year. In this case, both options are complete in season 3 but the one using the POSH is $46 MM USD cheaper.

- The $46 MM USD saved could secure an additional WTIV for 184 days (almost a full installation season). Using the 8.9 days per WTG result, this could amount to an additional 20 WTG units installed for the same total cost of the base feeder case. As the analysis model shows the POSH option is 20 WTG units short of project completion by the end of the second installation season, **the additional WTIV could allow the project to be completed by the end of the second season for the same cost of the base feeder case that progresses into season 3.**

7.10. POSH vs. Jack-Up Feeder Case

The arguments provided above against the "base feeder" also apply to the jack-up feeder case. While the jack-up feeder numbers are considered more realistic as they are based on actual met ocean data rather than an assumption of NPT, the associated cost overrun above the Sheet Harbor case is even larger ($72 MM USD). Again, both options have construction completing in the third season just 60 days apart. For a portion of the $72 MM USD saved, another vessel could easily reduce the timeline working from Sheet Harbor back into the second season with completion still being at a lower cost that the jack-up feeder case coming out of the US.

The overview presented in the attached appendix (section 16) is also to be considered in the interpretation of this jack-up feeder value comparison. The research of this study suggests that jack-ups with the deck space and cargo/jacking capacity to efficiently support large, serialized projects with 8+ MW turbines do not exist in the US. Build schedules for new feeders would put the earliest available units at least three years out from the writing of this report (2024).

To further this point, a discussion of the feeder vessel capabilities assumed in the Vineyard Wind case study is necessary. Once again reference is made to in the 2014 report provided to the DOE by GL Garrad Hassan titled "Assessment of Ports for Offshore Wind Development in the United States" and other references and sources cited in sections 14 and 15. The information provided therein was considered in building the general estimation of component size and mass for 8 – 10 MW WTGs, found in Table 12.

COMPONENT	Qty Per WTG	Length (m)	Max Width or Diameter (m)	Height (m)	Mass (t)
Monopile	1	90	9	NA	1719
Jacket	1	60	22	22	1000
Transition	1	20	10	NA	85
Tower	2	50	8	NA	175
Nacelle	1	20	10	10	400
Blade	3	80	5	2	50

Table 12 - Approximate Dimensions & Mass for WTG Components, 8 - 10 MW, 40m Water Depth

The analysis performed for Vineyard Wind has assumed a feeder vessel capable of transporting, at a minimum, one foundation or topsides set per trip such to keep up with the installation pace of the WTIV and, minimize cost to developers. In general, as the analysis above demonstrates, more feeder vessels mean increased daily spread cost to developers and more incremental NPT added to the installation schedule.

Considering the approach taken by the case study and the information in Table 12, the jack-up feeder vessels proposed would require the following bare minimum specifications considering the mass of a foundation and the deck space requirement of the topside main components. Note that these numbers account for main components themselves not including other frames, rigging, supporting equipment and minor pieces and, they assume the three blades are stacked in a purpose made frame and not laid side by each on the deck:

- **Length =** 100 m
- **Width =** 30 m
- **Cargo Jacking Capacity=** 1800 tonne

To assess the availability of US jack-ups (also called "Liftboats") meeting these specifications, Marcus Moore of ORECA engaged contacts with developers in the northeastern US to begin the search. At a later stage, Kalene Chandler of WESI was employed to build on the information assembled. Kalene spent over a week researching, extracting lists from existing studies as listed in section 15, and reviewing the BNOW OSW Supply Chain database for potential vessel providers. At the end of these combined efforts, 24 different potential US feeder vessel providers were identified. Most of these were contacted and provided WESI a summary of vessels in their fleet that would best suite offshore wind installation work.

In the context of the subject 'POSH vs. Jack-Up Feeder Case', the results are that US vessels meeting all above specifications, are not yet built. 2nd Wind Marine has completed a design for a "Super Feeder" vessel that is 124.5 m long, 40 m wide and capable of jacking up with 4000 tonnes of cargo onboard. For the turbine sizes planned for US OSW, this will be a purpose built, ideal design. Currently, discussions are ongoing with shipyards to determine cost and schedule of the build. The plan is to build two vessels but neither can be expected to be ready until at least 2024 at the current rate of progress.

As for the fleet of US jack-ups that exist, the longest is 56 m. There are ten vessels that have been identified that are 30 m wide or greater but, without the corresponding length, this is of little value for the transport of a complete WTG topside set. From the cargo jacking capacity perspective, there are no US vessels available with the capacity to jack-up with a complete topside (approximately 985 tonne), let alone a foundation based on the information presented in Table 12.

What this means for developers for at least the first half of the 2020's is that they will require either, more feeders per project than outlined in this report's Vineyard Wind Case Study and/or, they will need to employ large floating barges with no jacking capability to assist in construction. In either case daily spread cost, incremental NPT, or a combination of both will be increased above what this analysis presents. By this conclusion we again see further support for the benefits and minimization of installation risk provided using the POSH.

7.11. POSH vs. Barge Feeder Case

The results of table 11 are, to a degree, self-explanatory in this case however, there are two aspects that may be revisited in future study as data becomes available: **(i)** Floating barge day rate and **(ii)** incremental NPT number. It is likely that actual floating barge day rates may be lower than the $90 K USD used in this analysis. It is also possible that the 1.0 m Hs and 35% incremental NPT are high for this case. However, whatever changes may be realized to these values, it is not expected they will be significant enough to improve value over the POSH case.

7.12. US Manufacturing

As of the writing of this report, the US is without the capability to manufacture OSW main WTG components in country for the projected turbines sized 8 MW and larger. This fact is one of the pillars on which this opportunity study rests given that foundations, tower and transitions, nacelles, and blades all must be shipped to the northeastern US coast from Europe. In a situation in which components were made at or near planned OSW staging ports (which they will need to be due to size), installation complications implied by the Jones Act would remain but, there would be no reason or business case to use a Canadian port such as Sheet Harbor for project staging. Currently, onshore wind has a much larger presence in the US than offshore and, as such, there is US manufacturing that supports those projects. This fact has little impact on this study given that the specific design and sheer size of the main components for planned US offshore wind projects in the northeast cannot be manufactured and transported in large volume to the coast by land from existing manufacturing sites that support onshore wind.

Investments have been announced to develop main component manufacturing capability at or near US staging ports. Table 13 lists announced manufacturing investments or plans with the corresponding US port. The research of this study, which includes industry consultation by ORECA, suggests that the US may have the capability to support 2024's offshore construction with some foundations and 2025's with blades. As this is the only information on US manufacturing that could be uncovered relative to this scope, it has been concluded that US manufacturing will have little impact on the opportunities at Sheet Harbor between now and the later part of the decade.

Port:	Potential Manufacturing:
Brayton Point Commerce Center (Mass)	Generally described as "component manufacturing"
Sparrows Point Shipyard Industrial Complex (MD) - Trade Point Atl.	Land for "manufacturing development"
Bridgeport (CT)	Transition pieces
Port of Coeymans (GBS) (NY)	Gravity Bases
Paulsboro (NJ)	Monopiles
Salem, Hope Creek (NJ) - New Jersey Wind Port	Generally described as "component manufacturing"
SBMT (NY)	Generally described as "component manufacturing"
Port of Albany (NY)	Generally described as "component manufacturing"

Table 13 - Planned or Announced Investments in OSW Manufacturing in the Northeastern US

7.13. Canadian Ports – Why Sheet Harbor?

Following from the above assessment of the demand, and potential benefit, for OSW developers to stage (at least some) construction activity outside of the US, comes the question of which Canadian port option is best suited. The mandate of this report is to focus on Sheet Harbor, but the POSH facility may not be the only Canadian port considered for US OSW projects. Although the POSH meets, or can be made to meet, all the most important criteria for a staging port, there are other locations that have been identified with similar potential. In this section, those sites will be listed with the respective pros and cons they present for OSW construction staging operations. Each location's strengths and weaknesses will be briefly compared to Sheet Harbor. To maintain what is assumed as an economical distance from the project sites, only ports in New Brunswick and Nova Scotia have been considered. In consultation with ORECA, the following ports have been selected for this review: Mulgrave, Sydney, and Halifax in NS and, Saint John, in NB.

The main characteristics of the Mulgrave Marine Terminal were reviewed, and this location was quicky removed from consideration in the context of a comparison to Sheet Harbor. The two main determinants were the increased distance from the US and the limited acreage available for staging. Although the vessel access and berths at the terminal are well suited to large vessels, the site adds another 400 km (approximate) per round trip to the US OSW fields additional to the trip from Sheet Harbor. With only four acres of lay down area available, its maximum staging capability of approximately three complete WTG units does not justify the extra transit time and cost when compared to 30 units at Sheet Harbor.

Sydney Harbor in Nova Scotia is approximately twice the increased sail distance from Sheet Harbor as Mulgrave given its position further to the northeast. This location is planned to undergo a large new development (NovaPorte) which will include a 1600 m quayside and 500 acres of container terminal space. As the intent of these developments is for the core business of the terminal, container shipping and traffic, further investment and developments would be required to make the location ready for offshore wind staging. If such investments were made, they would be costly, and it is possible that resulting OSW operations may compete with the container shipping activities for berthing and quayside space. No additional area for wind staging has been discussed in addition to the container traffic upgrades. As Sydney is a further distance away from the US than Sheet Harbor and, not currently suited for OSW staging work, the harbor is not considered as viable an option as the POSH.

The third Nova Scotia port that has been considered is Halifax Harbor. The harbor is a large and multifaceted option with many terminals and port activities ongoing. Halifax is a very short distance closer to the US than Sheet Harbor and as such, presents only a small advantage from the perspective of installation round trip length and cost. Due to the restricted access to a large portion of the harbor limited by two bridges (47.5 m maximum air draft), large quayside storage areas for OSW staging are not currently available without considerable investment and time (i.e., conversion of a decommissioned oil refinery site). All current upgrades and developments in the Harbor are focused on expansion of existing cruise ship and container terminals. For these reasons, Halifax Harbor is considered an inferior and less suited option for OSW construction staging than Sheet Harbor.

Saint John, New Brunswick is the location that provides a Canadian Port option most comparable to Sheet Harbor. Available acreage for OSW development, totaling at approximately 46 acres exists in separate pieces of quayside land. Overall, the harbor has good access with a wide channel and no air draft restrictions. The total acreage available, although comparable to the POSH, is divided into several pieces throughout the harbor and, quayside access capability may need further development. Saint John is a comparable distance to the US offshore wind field to Sheet Harbor for the sake of determining installation round trip time and cost. The single complicating factor at Saint John that may deter developers is the potential impact of the extreme tides and currents. Early port comparisons have suggested this will cause additional vessel NPT in the form of "wait time" for quay access. For this reason and the associated unknowns, the POSH may be a preferred option to Saint John, NB within the scope of this review.

8. Objective 3 – The Dominion Energy Project and Regional Economics

In 2020, a consortium of companies and vessel owners working in support of the offshore installation of two 6 MW OSW WTGs for Dominion Energy's pilot project off the coast of Virginia (also known as the CVOSW Pilot Project) decided to use available space in Halifax Harbor to stage and prepare turbines for offshore installation. Given the small size of the project, the location was chosen as a cost and schedule effective way to avoid Jones Act related complications associated with the use of the project's foreign WTIV, the *Vole au Vent*. All WTG components arrived at Halifax on the transport vessel, *Big Roll Beaufort*. Due to the customs implications at the pier (which are not in place at POSH given that areas are bonded), no WTG components were loaded onto the quayside. Instead, all work was vessel to vessel with the use of onboard cranes. This was a minimal scope compared to even the lowest end of potential staging work for the port of Sheet Harbor. As such, extrapolating the potential economic benefits for the port from the CVOSW experience at Halifax provides a realistic, if not conservative result.

Given the early sensitivity and uncertainty around the acceptable use of Canadian ports for US OSW projects, details on this scope of work at Halifax were not readily provided. Fortunately, for the purposes of this study, the high level information required to assess the potential benefit of future OSW project involvement was obtainable or, could be estimated.

Table 14 provides a list of regional vendors who supported the scope and the services they provided. These scopes produced an approximate combined total of $4.27 MM USD contribution to the regional economy in 2020.

VENDOR	SERVICE
Atlantic Towing	Tugs for assisting docking/undocking
Airways Taxis	Airport transfers
Alantra	Trailer rentals for office and washroom facilities on site
AlumaSafeway	Erection of gangway support system
Atlantic Pilotage Authority	Compulsory pilotage services for moves in/out of the harbor
Bell Mobility	Data/Voice plans
Bluewater Ship Supply (some invoices invoiced directly to ship owners)	Catering/provisions
Bourque Security Services	Gangway and site security services
Chater Marine Supply	Supply of various items requested by crew/owners & in-bond movements of ship's equipment
Conrad's Transport	Transport of rental containers and delivery of rental fenders
CTS Container Rentals	Container Rentals
Dominion Diving (ROV service invoiced directly)	Launch services/offshore ROV services/sludge removal/fender install
Don Breton's	Inspection of survival suits
DoubleTree by Hilton	For required 14 day quarantine for all project related personnel
DSS Marine	Inspection of safety equipment
Eastern Fence	Crowd control barriers for control of site area
Edge Marine	Waste removal/garbage skip rentals
Empire Stevedoring (stevedoring expenses invoiced directly to JDN)	Line Handling and Stevedoring Services
Evershine Cleaning	Daily cleaning of on-site trailers

Herc Rentals	Rental of equipment such as cherry pickers
HOLMES MARITIME INC	Agency services and project/logistical support for installation and transport vessels
Irving Oil	Bunkers
Local plumber and electrician	For connection of on-site trailer units
Maritime Coach	For crew changes and transfers
PF Collins	Customs clearance services
Praxair	Rental/supply of gas cylinders
Praxes	Covid Testing, medical support contract
Radio Holland	Servicing of ship's equipment
Seamont	In-bond movement of spares/crew medical
Shipp Pharmacy	Filing of crew medical prescriptions
Strictly Hydraulics	Hydraulic hose repair
TJ Engineering	Rope Access Technicians for works inside towers units
TRC Hydraulics	Testing/troubleshooting/repair of equipment related to crane issue

Table 14 - Regional Vendors who supported the 2020 CVOSW Pilot Project

8.1. Use of the CVOSW Project Regional Economics

The anticipated activities at the port of Sheet Harbor are expected to be much greater in scope than those summarized above which, as previously stated, suggest that estimates based on this data will be conservative. In this effort, this study will apply a simple regional economic benefit factor to future US OSW staging at Sheet Harbor that is based on a project's total construction capital (CAPEX) cost. Total CAPEX is widely documented for the CVOSW project and, as subsequent sections of this report will demonstrate, may be easily predicted for future projects using a range of industry accepted USD/kW CAPEX multiplication factors.

WESI sources at Aegir Insights have reported that USD/kW capital expenditure numbers for the future OSW projects in the northeastern US will range somewhere between $3000 and $4500 while other sources predict even higher. As the first project of its kind and due to other aspects beyond the scope of this report, the CVOSW Pilot Project achieved a staggering $25000 USD/kW CAPEX ratio for total capital investment of $300 MM USD. By division, this means the regional, $4.27 MM of economic impact in Nova Scotia amounted to the 1.42% of that project's total capital spending.

Although conservative, this 1.42% number will be applied in the regional benefit prediction associated with Sheet Harbor against future projects in the following report sections.

9. Objective 4 – Predictions on the use of Sheet Harbor

To begin forming a realistic prediction on the actual use of Sheet Harbor for OSW construction staging, a process like the one used to select the case study project, Vineyard Wind, was applied. Also, given that the value proposition for the site uses Vineyard Wind, it was concluded that other projects within the same northern cluster with specifications comparable to Vineyard, should also be used to predict activity at Sheet Harbor. Conveniently, the Vineyard Wind, Mayflower Wind and Park City Wind projects, which are all 800 MW projects, are set to undergo construction consecutively in the three, near term peak construction years as identified previously in this report, i.e., 2023, 2024 and 2025. Based on the benefits as defined in the value analysis above, this study forecasts the Port of Sheet Harbor to have some involvement in staging for each of these three projects if the required site investments are made and, POSH is successfully marketed to developers, suppliers, and vessel owners. Granted other projects may also come into play during these or other years which will only add to the base ROI being predicted from Vineyard, Mayflower and Park City. The potential of projects additional to these three is discussed in section 10.2, “Extended Potential”.

Another requirement to predict activity at Sheet Harbor is to determine how many WTGs (or equivalent WTG total units) the site is likely to stage within a given construction year for the chosen projects. To do this, basic math is applied starting on the assumption that the upgraded facility may store/stage as many as 30 equivalent WTG total units at a time (assumption verified in reference documentation supplied by NSBI based on approximately $3.0 MM USD initial investment). Further analysis assumes, in the *maximum* use case, efforts would be made to have the 30 unit components shipped to the staging harbor prior to, or at the very beginning of the installation season. If installation is to begin immediately, over the course of the season, a single WTIV may turn over an additional 23 WTG equivalent total units. This number is arrived by dividing season length (210 days) by the average days per WTG install as determined previously in this report (8.9 days, Table 11). As such, regardless of the demand, the analysis in section 10 below assumes that the Port of Sheet Harbor may store no more than 53 equivalent WTG total units over the course of any given installation season. Further discussion on this assumption with ORECA suggests that in using a WTIV only, there may be potential to extend the installation season into the winter months, i.e., make it longer than 210 days. In such a case, revenues and returns on investment (ROI) as predicted in section 10 would be larger.

In each project selected for this prediction, total WTGs exceeds 53 and therefore, 53 units will be used as the maximum use case, per year at Sheet Harbor. This study has also defined medium and minimum use cases for the site which are respectively 47% and 9.5% of the maximum or, 25 and 5 total WTG units per season.

In the following section, these three totals will be applied to projects using two different total CAPEX expenditure predictions.

10. Objective 5 – Range of Economic Benefits for Sheet Harbor

The final piece in producing the desired output of this study is the prediction of total capital cost for the selected projects namely, Vineyard Wind, Mayflower Wind, Park City Wind and potentially others in future years. The OSW industry uses an established practice of forecasting CAPEX using a total project 'USD per kW' number which includes the cost of cabling and transmission in addition to WTG component procurement and offshore WTG construction. Figure 7, provided by study source Aegir Insights, demonstrates the potential variability in this constant for different projects around the world.

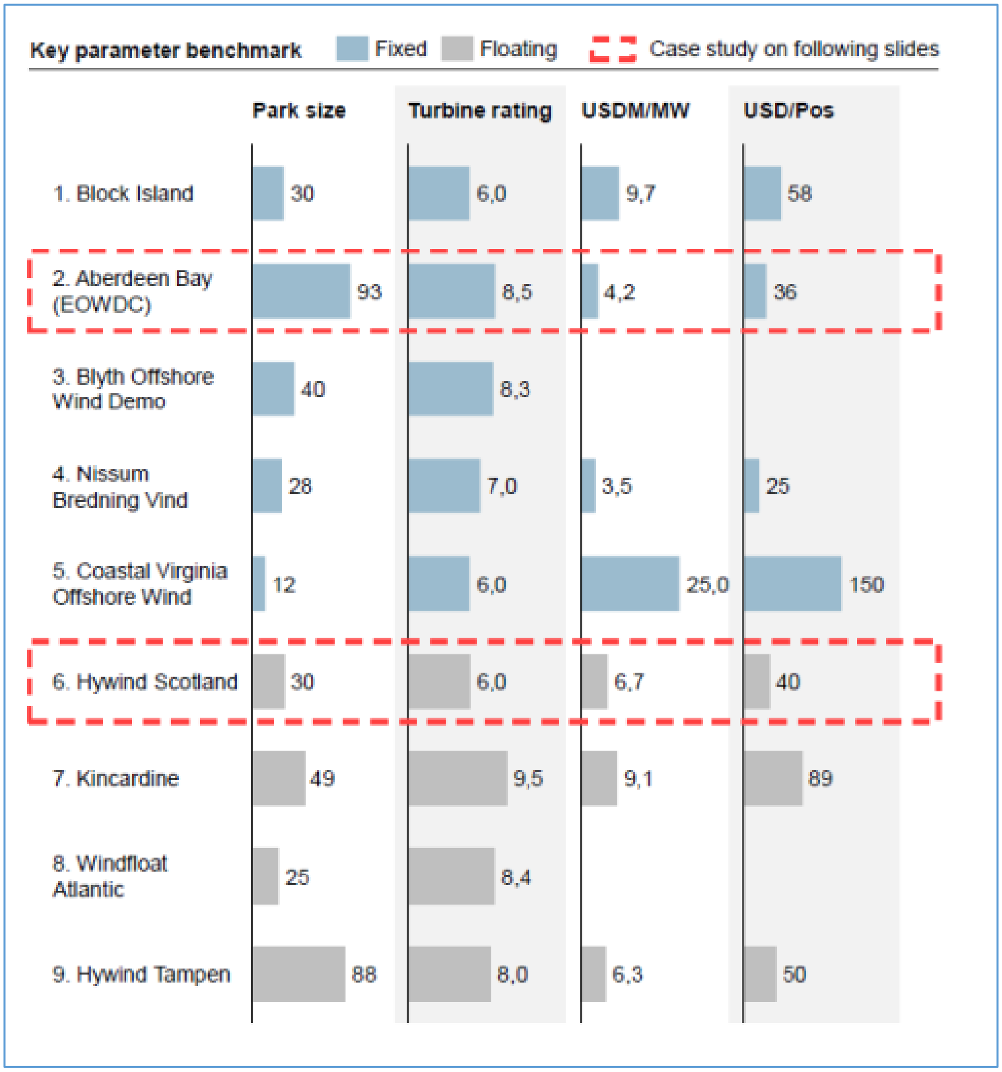


Figure 7 - Potential Variability of CAPEX Cost for OSW Project Installation

For obvious reasons, early fixed OSW projects in the US have proven to be completed at much higher USD/kW CAPEX costs than those in Europe. Experience, distance to component supply, vessel availability and cost of labor would be just a few reasons why. Other sources provide the following predictions for the northeastern US:

- American Wind Energy Association Report "*U.S. Offshore Wind Power Economic Impact Assessment – March 2020*" - **$3900 USD/kW**
- BVG Associates Analysis – *https://guidetoanoffshorewindfarm.com/wind-farm-costs* - **$3200 USD/kW**

- Review of 'Robin Rigg' OSW Project, UK, 2008 - https://www.wind-energy-the-facts.org/development-and-investment-costs-of-offshore-wind-power.html **- $3143 USD/kW**
- NREL Annual Technology Baseline 2019 **- $4633 USD/kW**
- Navigant *"Offshore Wind market and Economic Analysis – Annual Market Assessment",* prepared for US DOE in 2013 **- $6040 USD/kW**

In consultation with Aegir Insights, it was decided that $3000 and 4500 USD/kW are sound numbers to realistically predict the range in cost for the subject US projects.

Using these values, the resulting output is provided in Table 15. Based on the predictions discussed in section 9, the table presents the Vineyard, Mayflower and Park City Wind projects as those with a high potential of utilizing POSH and with construction activities likely coming in sequence across 2023, 2024 and 2025, respectively. Based on the project size in MW, total capital cost for each project is estimated using the minimum and maximum estimates of USD/kW as stated above as $3000 and $4500, respectively. These are labelled 'BC1' and 'BC 2' in the table. Using the total capital cost estimates, six different revenue scenarios are calculated, per project as follows. First, the 1.42% factor based on the previous staging activity in Halifax Harbor as discussed above is applied. Then the maximum (53 WTG), medium (25) and minimum (5 WTG) activity cases based on Sheet Harbor's capabilities are each applied as percentages of total project WTG quantity. As such a maximum, medium, and minimum revenue cases for each BC 1 and BC 2 are calculated per project thus producing six revenue scenarios for each year.

Over the three years (2023 – 2025) and three projects, combined revenue for each of the six scenarios is totaled. The final calculation is performed in the last column of the table where the return for investment in the port is calculated. Table 15 uses $3.0 MM USD as an initial investment number based on engineering studies completed for POSH (listed in report references) to determine the minimum cost associated with achieving 30 WTG capability.

ROI calculations and interpretation of the results of Table 15 are provided in section 10.1.

CONSTRUCTION YEAR	2023	2024	2025	TOTALS	ROI *Assuming $3.0 MM USD Initial Investment*
PROJECT	VINEYARD	MAYFLOWER	PARK CITY		
PROJECT SIZE (MW)	800	804	804	2408	
QUANTITY OF WTG UNITS	67	80	67	214	
EST. CAPITAL COST (AT 3000 USD/KW) - BENEFIT CASE 1 (BC1) (USD)	$2,400,000,000	$2,412,000,000	$2,412,000,000	$7,224,000,000	
EST. CAPITAL COST (AT 4500 USD/KW) - BENEFIT CASE 2 (BC2) (USD)	$3,600,000,000	$3,618,000,000	$3,618,000,000	$10,836,000,000	
POSH MAX. (53 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	79%	66%	79%		
POSH MED. (25 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	37%	31%	37%		
POSH MIN. (5 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	7%	6%	7%		
LOCAL BENEFITS FACTOR (PERCENTAGE OF TOTAL	0.0142	0.0142	0.0142		

CAPEX) FROM CVOSW PILOT - 1.42%					
MAX. PREDICTED REGIONAL BENEFIT (USD) - BC1	$26,958,805	$22,690,890	$27,093,600	**$76,743,296**	***1279%***
MED. PREDICTED REGIONAL BENEFIT (USD) - BC1	$12,716,417	$10,703,250	$12,780,000	**$36,199,668**	***567%***
MIN. PREDICTED REGIONAL BENEFIT (USD) - BC1	$2,543,283	$2,140,650	$2,556,000	**$7,239,934**	***57%***
MAX. PREDICTED REGIONAL BENEFIT (USD) - BC2	$40,438,208	$34,036,335	$40,640,400	**$115,114,944**	***1965%***
MED. PREDICTED REGIONAL BENEFIT (USD) - BC2	$19,074,626	$16,054,875	$19,170,000	**$54,299,502**	***885%***
MIN. PREDICTED REGIONAL BENEFIT (USD) - BC2	$3,814,925	$3,210,975	$3,834,000	**$10,859,900**	***121%***

Table 15 - Potential ROI for $3.0MM Investment in POSH based on activity & OSW Project CAPEX 2023 - 2025

10.1. Return on Investment (ROI)

The assistance of WESI's corporate controller was sought to review results and calculate the potential return on investment for the Port of Sheet Harbor. Site data provided by NSBI justified the approximate $3.0 MM USD minimum investment required for the port to achieve approximately 30 WTG storage capability. Other assumptions made:

- Currency Risk. It is assumed the USD/CAD exchange rate will remain stable.
- Opportunity Cost of Capital – 10%
- 30% corporate taxes
- Initial Investment occurs in 2021.

Using the information above, the following formula is used to calculate the ROI:

Estimated ROI = (Net Return After Tax / Total Investment Cost) x 100%

Estimated ROI was calculated by computing the Present Value (PV) to Year 0 (zero) of all the estimated cash outflows/inflows provided, using the assumptions listed, including 10% cost of capital. The outflow of $3M was assumed to occur now (Year 0 = 2021), and the PV of the cash inflows in the future were divided by 1.10 for each year in the future they are estimated to occur, to compute their PV now in Year 0 (2021). The PV of all the Cash outflows/inflows were then added up to get the column "Year 0 Net Before Taxes". 30% corporate taxes were then removed to get the Column "Year 0 Net Return After Taxes". Estimated ROI was then calculated with the formula outlined above.

As a calculated ROI of 100% is 'break even', the results of Table 15 indicate that four of the six cases presented are extremely profitable, one case is marginally profitable and one case projects a loss.

10.2. Extended Potential

By focusing on just three projects, the economic benefits presented above represent only a fraction of the potential, longer term opportunity if the POSH was to become an established OSW staging location. However, as this study makes clear, the port market in this developing industry is set to become more competitive as the decade progresses. As the information of this report makes clear, long term activity is a very real possibility when the current backlog and, future potential of projects is considered.

To further the analysis for a long term case, to approximately 2030, eight projects planned in the northeastern cluster in closest proximity to Sheet Harbor were assessed. Considering the immaturity of the industry and the fact that approvals are still not issued, for the sake of the additional analysis of this section, the reasonable assumption is made that installation schedules as currently known or announced will shift. The volume of work currently planned between 2022 and 2026 is immense and possibly, not achievable. Table 16 was developed to show an alternate prediction of the projects closest to the POSH, with peak construction years during which the facility may see the maximum, medium or minimum levels of activity as presented in sections above. It is taken for granted that investment beyond the initial $3.0 MM USD would be required to make this long term activity possible.

PROJECT	YEAR
VINEYARD	2023
REVOLUTION	2024
BAY STATE	2025
MAYFLOWER	2026
SUNRISE	2027
PARK CITY	2028
LIBERTY	2029
BEACON	2030

Table 16 - Alternate, Long Term Prediction for Activity at POSH

With appropriate investment, this long term activity is considered very possible when the Vineyard Wind Case study is considered. The locations, and therefore corresponding distances to US ports and POSH do not vary a great deal between these eight projects and therefore, this section will assume the economics and supporting business case for each staging from Sheet Harbor will be consistent.

The details of these projects were assembled in an expanded revision of table 15. The ROI column for the $3.0 MM USD was replaced with the two alternate scenarios of $20.0 MM and $35.0 MM USD, respectively. The ROI calculation assumes these investments are made from 2021 – 2023. The average and totals of the eight projects and the corresponding ROIs for these two investment cases are provided in table 17.

CONSTRUCTION YEAR	2023 - 2030		ROI *Assuming $20.0 MM USD Initial Investment*	ROI *Assuming $35.0 MM USD Initial Investment*
ALL PROJECTS (Table 16)	AVERAGES	TOTALS		
PROJECT SIZE (MW)	984.75	7878		
QUANTITY OF WTG UNITS	95.125	155		
EST. CAPITAL COST (AT 3000 USD/KW) - BENEFIT CASE 1 (BC1) (USD)	$2,954,250,000	$4,500,000,000		
EST. CAPITAL COST (AT 4500 USD/KW) - BENEFIT CASE 2 (BC2) (USD)	$4,431,375,000	$6,750,000,000		
POSH MAX. (53 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	59%			

POSH MED. (25 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	28%			
POSH MIN. (5 WTG) AS PERCENTAGE OF TOTAL PROJECT STAGING	6%			
LOCAL BENEFITS FACTOR (PERCENTAGE OF TOTAL CAPEX) FROM CVOSW PILOT - 1.42%	0.0142			
MAX. PREDICTED REGIONAL BENEFIT (USD) - BC1	$23,623,580	**$188,988,637**	***333%***	***163%***
MED. PREDICTED REGIONAL BENEFIT (USD) - BC1	$11,143,198	**$89,145,584**	***123%***	***43%***
MIN. PREDICTED REGIONAL BENEFIT (USD) - BC1	$2,228,640	**$17,829,117**	***-26%***	***-42%***
MAX. PREDICTED REGIONAL BENEFIT (USD) - BC2	$35,435,369	**$283,482,956**	***531%***	***276%***
MED. PREDICTED REGIONAL BENEFIT (USD) - BC2	$16,714,797	**$133,718,375**	***217%***	***96%***
MIN. PREDICTED REGIONAL BENEFIT (USD) - BC2	$3,342,959	**$26,743,675**	***-8%***	***-32%***

Table 17 - Potential ROI for Long Term Activity at Sheet Harbor for $20.0 MM and $35.0 MM USD Investment Cases

In the $20 MM USD total investment case, three revenue scenarios are very profitable, one is marginally profitable and two project a loss.

In the $35 MM USD total investment case, only one scenario (maximum activity, BC2) shows a high profit rate of return while maximum activity for BC1 is moderately profitable. The other four scenarios in this investment case are near breakeven, or project a significant loss.

The results of section 10.1 and 10.2, in combination may be simply understood as defining three separate scenarios:

I. $3.0 MM USD investment in the POSH in 2021-2022 for predicted revenue from three projects (Vineyard Wind, Mayflower Wind and Park City Wind) from 2023 – 2025
II. $20.0 MM USD investment in the POSH in 2021-2023 for predicted revenue from eight projects (Vineyard, Revolution, Bay State, Mayflower, Sunrise, Park City, Liberty and Beacon) from 2023 – 2030
III. $35.0 MM USD investment in the POSH in 2021-2023 for predicted revenue from eight projects (Vineyard, Revolution, Bay State, Mayflower, Sunrise, Park City, Liberty and Beacon) from 2023 – 2030

Averaged, the results of the revenue predictions and the associated ROI are as follows:

SCENARIO I – Average ROI of **812%** - **Profitable**
SCENARIO II – Average ROI of **195%** - **Profitable**
SCENARIO III – Average ROI of **84%** - **NOT Profitable**

The extended, larger investment results should be considered in light of the conservative methods applied to these predictions. That is to say, the use of the 1.42% multiplication factor discussed above and the maximum CAPEX prediction for the subject projects, $4500 USD/kW, which may well be exceeded. Also, to be factored in are the opportunities that may exist beyond 2030. Information presented above in this report for state targets to 2035, pending lease auctions and new projects all support the prediction that, once established, activities at the POSH may continue into the 2030's thus improving these returns for the initial investments proposed.

11. Other Opportunities

The main infrastructural challenges of OSW project installation, i.e., ports and vessels, have been shown to provide a business case for the development of Sheet Harbor as applied to WTG staging and offshore construction alone. However, there are other aspects of the complete construction process that also require the support of port infrastructure and specialized vessels that carry the common themes and challenges relevant to the installation of WTGs themselves which are: import and transport of foreign goods and, potential complications in the US produced by the Jones Act. Although this report has not studied or explored these opportunities, they are worth mentioning in that any support POSH can provide for these aspects, will translate into further and increased economic opportunity for the port. These aspects are namely, seabed cable installation and scour protection (rock supply and dumping).

11.1. Seabed Cable Installation

All offshore wind farms utilize two primary types of cables or cable systems for the transmission of the power generated to shore namely, export cable and array cable. The export cable is the single tie from the wind farm to shore where it is transformed and connected to the land based grid via substation. The array cables, also called inter-array cables, are those that tie individual WTGs together within a farm. Array cables generally tie into the offshore substation before the power is converted and sent to shore via the main export cable. The detailed specifications of these cables will not be discussed here aside from the general comment that they are large, specialty cables not commonly available in all regions. Although some of these cables may be manufactured and provided within the US in future, there is reason to believe some, if not the majority, will be supplied by European manufacturers who have years of experience in this field from OSW activities in those waters. For the US projects subject to this study, the data gathered estimates approximately 1500 km of export cable and 2800 km of inter array cable will be installed within the next decade. As with all aspects of OSW construction, these activities will be large in scale. They will require large vessels for transport and installation, heavy lifts, trenching and burying activities, quayside spooling, cutting and termination capabilities, among other requirements. Installation may be achieved with specialized vessels with purpose designed cable carousels or, by use of other vessels retrofitted to accommodate spools and pay out to the seabed. Initial observations are that the latter may be provided within the US while it is most likely the former (specialty vessels) will be foreign. Again, if cables come from Europe and foreign vessels are used for installation, there may be opportunities generated in this area for the POSH.

It is important to note however that the distinct differences between the cable-lay discussion and that of WTGs may be significant. Specifically:

- Foreign specialty vessels may be adequate for the transport of the cables from Europe and the installation activities. In such cases, vessels may stop in the US for fuel and then go directly to the field for installation which, in the case of these cable systems for some projects, may be completed within a trip.
- The single trip removes the confinements of the Jones Act for the sake of export cable installation and, smaller array cable scopes. However, large array cable scopes may require multiple trips.
- Unlike the WTG units themselves, the seabed, may not be interpreted as a US Port by those that monitor, review, and approve proposals in accordance with the Jones Act.

The approach for cable installation will vary by project and developer and as such, a more detailed analysis of the items discussed above, and some project specific study would be required to accurately predict opportunities for Sheet Harbor in this area of OSW project installation.

11.2. Scour Protection (Rock Supply and Dumping)

Scour protection describes the work done on the seabed to protect OSW Farm components and cables from the costly damage that could be incurred by ice bergs, arrant or sinking vessels, anchors, fishing activities, etc. As with the cable lay aspects of offshore construction, this area has not been studied in detail in this report. However, the subject has been reviewed with enough attention to make the general observation that the installation of scour protection requires an extremely large quantity of rock. Again, the activities are very large in scale. Information acquired from Nova Scotia Business Inc. (NSBI) in support of this study suggests that the type of rock developers use for this work is of a specific variety not readily available on the east coast of North America. *Eclogite* is one variety of rock used for its unique density (3.1 t/m3). Such rock must be imported by vessel from other countries such as Norway. The quantity of rock required for OSW projects like those proposed in the northeastern US is in the order of multiple hundred thousand of metric tonnes (per project).

If specialized rock of these quantities is to be delivered to North America from Europe, it will need to be offloaded, stored and onloaded to specialized rock dumping vessels. Again, port access, space, specialized vessel availability and the Jones Act are very likely to come into play such to create opportunities for Sheet Harbor associated with these activities.

According to NSBI, inquires have already been made about using the POSH for these purposes.

11.3. General

Offshore wind is still a new industry for the northeastern US, while this study, and the viability of the use of Sheet Harbor has been performed with the primary offshore installation challenges considered, there have been other areas noted where there will be demand in the region. These areas may be considered ancillary and not necessarily specific to the POSH. Instead, they are for consideration as opportunities that would be provided at or near the port. The list of these opportunities includes but is not limited to:

- Outfitting of components (nacelles and towers)
  - Lighting
  - Access, ladders, etc.
  - Fire & Gas and other Safety Systems
- Provision of specialized piling equipment (i.e., hydro hammers and associated rigging)
- Subsea pump skids for evacuation of suction piles
- Specialized, engineered rigging, spreader beams and lifting apparatus for main components.
- Frames and securing for frame components (i.e., Blade Racks)

With more research, it is expected this list would be significantly expanded.

12. Drone Survey

AVCI completed a drone survey of the POSH site to capture georeferenced 3D model and images that may be used for future purposes by OERA, NSBI or other stakeholders. The end deliverables of the campaign are yet to be finalized to achieve the result best suited for further marketing, engineering and/or planning in relation to the site's use in OSW staging activities. Figure 8 is provided as a preview of these final product(s) displaying scale example of 10 MW WTG components staged at Sheet Harbor.

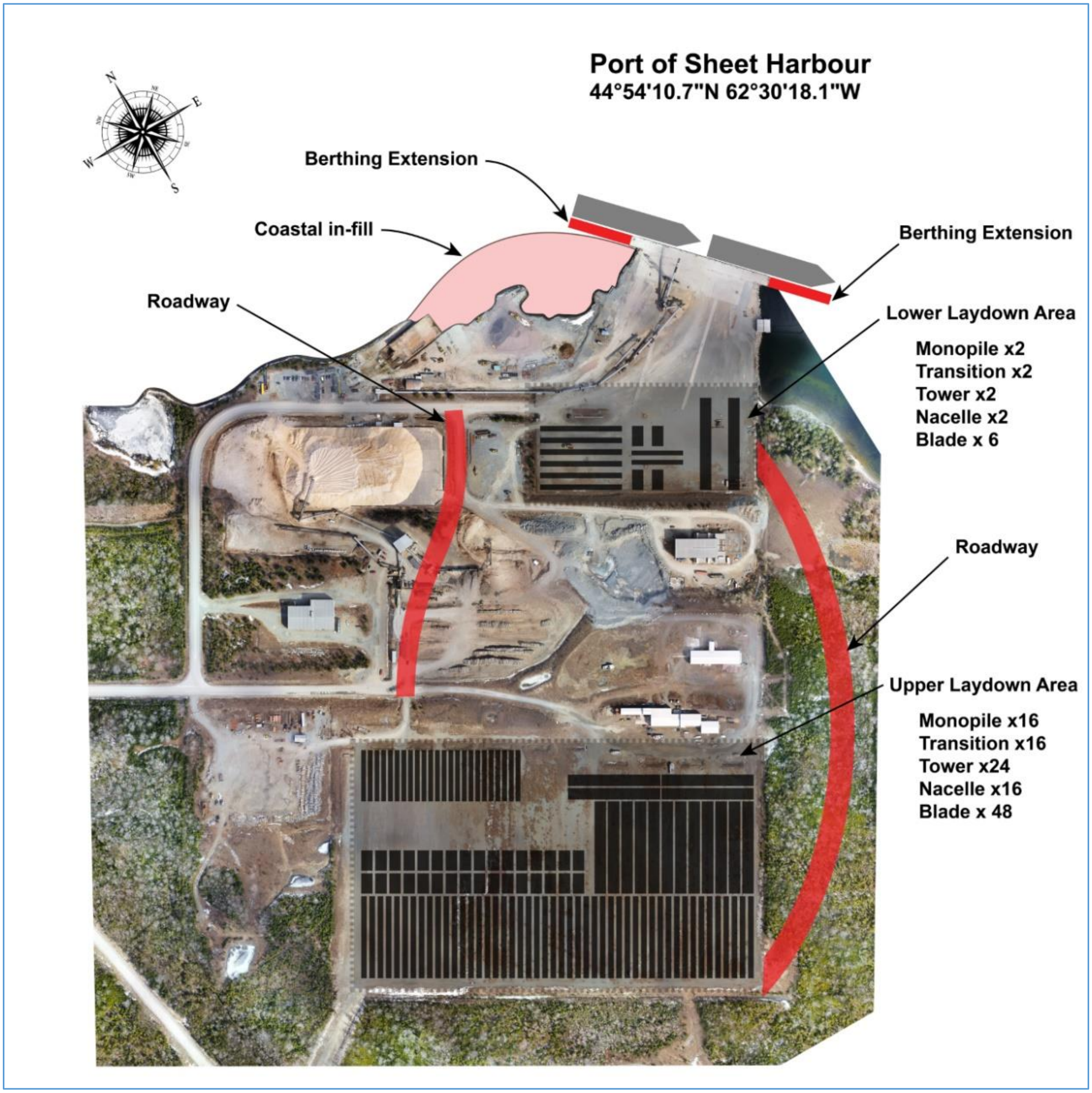


Figure 8 - Example Output of AVCI Drone Survey

13. Conclusions

There is ample evidence to support significant OSW "window of opportunity" for Atlantic Canadian ports such as Sheet Harbor. This is due in part to an imminent surge in OSW construction activity in the northeastern US seems apparent when analyzing the agenda and commitments already made by the recently installed US Federal Government and President Biden. The information collected makes it clear that approximately 20 projects across 8 northeastern states for a total of 19.5 GW of offshore wind power contribution are ready to move forward. Nearly 6.5 GW of that power has already been purchased or agreed for offtake by various states. This data is evidence enough of the activity soon to be realized without considering the additional power required to meet state targets for 2035 and the large, uncontrolled lease areas set to be auctioned later this year.

Although dependent on timing of OSW project approvals, this assessment makes it clear that the port infrastructure required to support the potential volume of offshore construction is not available in the northeastern US alone. Developers such as Vineyard Wind have named Sheet Harbor specifically as a potential supporting location in plan documents submitted to BOEM for the project. The basic analysis performed, based primarily on the requirements for quayside staging acreage, is aligned with those indications.

The attractiveness of POSH (plus other suitable Canadian ports) to developers and installers is that a foreign WTIV can freely transit to and from the OSW construction locations. This same foreign WTIV cannot freely transit within the USA due to the Jones Act. In many cases, this is a more cost effective and lower risk alternative to the use of multiple feeder vessels and floating barges. Multiple feeder vessels and barges result in increased daily spread cost (e.g., fuel, equipment, personnel) and non-productive time (NPT) which are detrimental to project economics. This is the value proposition offered by POSH, or other suitable Canadian ports.

Using the information available from the CVOSW Project experience at Halifax in 2020, and by extensive research into the likely total capital costs of future US projects, realistic predictions of the potential economic benefits for Sheet Harbor have been obtained. The resulting returns and prolonged activity and job creation provide further support to the viability of the business case at the POSH.

Many ancillary port activities crucial to wind farm construction that are beyond the work associated with the WTGs have not been studied in this report. Opportunities related to subsea cable staging, preparation and installation, rock storage and dumping for subsea scour protection, and other general services require further analysis but offer additional opportunity for ports such as Sheet Harbor.

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16. Appendix – Potential US Feeder Vessel Fleet

US Offshore Wind - "FEEDER" Vessel Supply Chain						
Type	**Company**	**Vessel Name**	**Quantity**	**Length (m)**	**Breadth (m)**	**Deck/Jacking capacity (t)**
Barge	Diamond Services	B/V SF-2200	1	67.1	21.96	Unknown
Barge	Diamond Services	B/V Hawkeye	1	62.525	16.47	Unknown
Barge	Diamond Services	B/V HOR100	1	62.525	16.165	Unknown
Barge	Donjon Marine Co Inc	Witte 5001	1	73.2	21.96	4
Barge	Foss	Aquatrain	1	129.625	30.5	Unknown
Barge	Foss	American Trader	1	122	32.025	Unknown
Barge	Foss	Foss 3612	1	109.8	36.6	Unknown
Barge	Foss	286-3	1	87.2605	23.18	Unknown
Barge	Foss	Ninilchik	1	79.3	21.96	Unknown
Barge	Foss	AMS 250	1	72.773	21.35	Unknown
Barge	McDonough	MARMAC 15-20	5	76.25	21.96	4819
Barge	McDonough	MARMAC 21-32	12	79.3	21.96	4500-5300
Barge	McDonough	MARMAC 300	4	79.3	30.5	6477
Barge	McDonough	MARMAC 301	5	91.5	30.5	10267
Barge	McDonough	MARMAC 400	1	122	30.5	11453
Barge	Weeks Marine	Weeks 97	1	76.25	16.47	TBC
Barge	Weeks Marine	Weeks 99	1	91.5	21.96	6
Barge	Weeks Marine	Weeks 176	1	42.7	12.2	1587.6
Barge	Weeks Marine	Weeks 177	1	42.7	12.2	1587.6
Barge	Weeks Marine	Weeks 178	1	42.7	12.2	1587.6
Barge	Weeks Marine	Weeks 179	1	42.7	12.2	1587.6
Barge	Weeks Marine	Weeks 184	1	45.75	12.2	589.7
Barge	Weeks Marine	Weeks 185	1	45.75	12.2	589.7
Barge	Weeks Marine	Weeks 186	1	45.75	12.2	589.7
Barge	Weeks Marine	Weeks 188	1	45.75	12.2	589.7
Barge	Weeks Marine	Weeks 242	1	53.375	22.875	TBA
Barge	Weeks Marine	Weeks 290	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 291	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 292	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 293	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 294	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 295	1	54.9	16.47	3742.14
Barge	Weeks Marine	Weeks 297	1	76.25	22.875	7
Barge	Weeks Marine	Weeks 298	1	54.9	16.47	3742.14
Barge	Weeks Marine	2220 Series	1	67.1	18.3	4740.04
Barge	Weeks Marine	Weeks 2221	1	67.71	18.3	4740.04

Barge	Weeks Marine	Weeks 2222	1	67.71	18.3	4740.04
Barge	Weeks Marine	Weeks 2600	1	79.3	21.96	24
Barge	Weeks Marine	Weeks 2701	1	103.7	23.79	11725.37
Barge	Weeks Marine	Weeks 2702	1	103.7	23.79	TBC
Barge	Weeks Marine	Weeks 2900	1	54.9	16.47	3383.80
Barge	Weeks Marine	Weeks 2901	1	54.9	16.47	3383.80
Crane Barge	Donjon Marine Co Inc	Chesapeake 1000	1	58.255	30.5	N/A
Crane Barge	Donjon Marine Co Inc	Colombia NY	1	76.25	21.96	Unknown
Crane Barge	Donjon Marine Co Inc	Farrel 256	1	61	17.08	Unknown
Crane Barge	Manson Construction	E.P.Paup	1	115.9	32.025	TBC
Crane Barge	Manson Construction	Haakon	1	85.4	20.74	TBC
Crane Barge	Weeks Marine	Weeks 533	1	94.55	30.5	TBC
Deck Barge	Tappan Zee Constructors	TZC 104	1	73.2	21.96	
Deck Spud Barge	Donjon Marine Co Inc	Stepping Stone	1	61	17.08	Unknown
Deck Spud Barge	Weeks Marine	Weeks 752 (RD MacDonald)	1	79.3	24	130
Derrick Barge	Tappan Zee Constructors	1750MT Derrick Barge	1	117.12	30.43	
Feeder Jack up	2nd Wind Marine	TBC	2	124.5	40	4000
Liftboat	Seacor Marine	Robert	1	56	41	680.4
Liftboat	Seacor Marine	Jill	1	56	41	680
Liftboat	Seacor Marine	Power	1	50	36.6	614
Liftboat	Seacor Marine	Legacy	1	47.7	36.6	609
Liftboat	Seacor Marine	Influence	1	44	33.5	485
Liftboat	Seacor Marine	Respect	1	44	33.5	485
Liftboat	All Coast	Great White	1	45.26	32.61	362.8
Liftboat	Seacor Marine	Kayd	1	42.3	30.8	431
Liftboat	Seacor Marine	Myrtle	1	42.3	30.8	431
Liftboat	Seacor Marine	Hawk	1	41.94	29.92	354
Liftboat	Seacor Marine	Caitlin	1	42.2	26.2	386
Liftboat	Seacor Marine	Paul	1	42.2	26.2	386
Liftboat	Aries Marine	RAM XIX	1	41.76	24.38	568.1
Liftboat	All Coast	Man O War	1	40.7	24	226.8
Liftboat	Offshore Marine Contractors	Tobie Eymard	1	41.785	22.57	453.59
Liftboat	Offshore Marine Contractors	Jaime Eymard	1	41.785	22.57	453.59
Liftboat	Offshore Marine Contractors	Lacie Eymard	1	41.785	22.57	453.59

Liftboat	Offshore Marine Contractors	Michael Eymard	1	41.785	22.57	453.5
Liftboat	Aries Marine	RAM XIV	1	35.075	22.57	362.8
Liftboat	Aries Marine	RAM XII	1	35.075	22.57	362.8
Liftboat	Offshore Marine Contractors	Olivia Grace	1	35.075	22.57	344.73
Offshore Support Vessel	Northstar Marine	Commander	1	73.15	17	1320.86
PSV	Seacor Marine	Brave	1	61.31	14.64	812
PSV	Seacor Marine	Chief	1	61.31	14.64	812
PSV	Seacor Marine	Fearless	1	61.31	14.64	812
PSV	Seacor Marine	Mixteca	1	67.466	14.64	1016
PSV	Seacor Marine	Resolute	1	61.31	14.64	812
Shear Leg	Tappan Zee Constructors	Left Coast Lifter	1	117.12	30.5	N/A
WTIV	Dominion	Charybdis	1	143.96	56.12	TBC
TBD	Hughes Marine	Awaiting details		0	0	
TBD	Laredo Group	Brazos				
TBD	Orion Marine	Awaiting details		0	0	

**** END OF REPORT ****