DMDE Engineering

Socio-economic Report

Port Development and Port Usage for Regional Assessment Committee

Offshore Wind Development in Nova Scotia

September 2024

September 17, 2024

Ann Wilkie / James Wooder
Co-chairs Regional Assessment Committee
Offshore Wind Development in Nova Scotia

Dear Ms. Wilkie and Mr. Wooder:

Subject: Socio-economic Report – Port Development and Port Usage – Offshore Wind Development in Nova Scotia – DMDE Report

DMDE Engineering Limited (DMDE) is pleased to submit this Report studying the socioeconomic benefits for the Province of Nova Scotia.

This Report reviews the supply chain requirements at the ports in Nova Scotia for the offshore wind industry.

The Report analyzes the current capacity of the ports in Nova Scotia, where additional capacity is required, concepts for increasing capacity of existing wharfs, and concepts for new port structures.

This Report also looks at the socio-economic benefits related to the port operations for receiving, storing and transhipping offshore wind components, construction of elements, and presenting the socio-economic benefits for the province as it relates to offshore wind farms.

The following Chapters of this Report describe the benefits in more detail.

Yours truly,

<Original signed by>

Dan MacDonald, M.A.Sc., P.Eng., FEC, FCSSE
President
DMDE Engineering Limited
Phone: 902-565-7682
E-Mail: danmacdonald@dmde.ca

Contents

1. Introduction

Many studies and reports have identified the richness of the wind resource off Nova Scotian shores and the need to capitalize upon that resource to decarbonize sources of energy. The federal and provincial governments have acted on that. Pursuant to an Agreement reached between the Government of Canada and the Province of Nova Scotia on 23 March 2023, Terms of Reference were established to guide a Regional Assessment (the RA) focused on examining the potential for offshore wind (OSW) development in the waters off Nova Scotia. A five-person independent committee (the Committee) was appointed to undertake the RA; the Committee commenced work in April 2023. The Report Area, shown in Figure 1, is approximately 300,000 km2 and includes the continental shelf and slope off Nova Scotia.

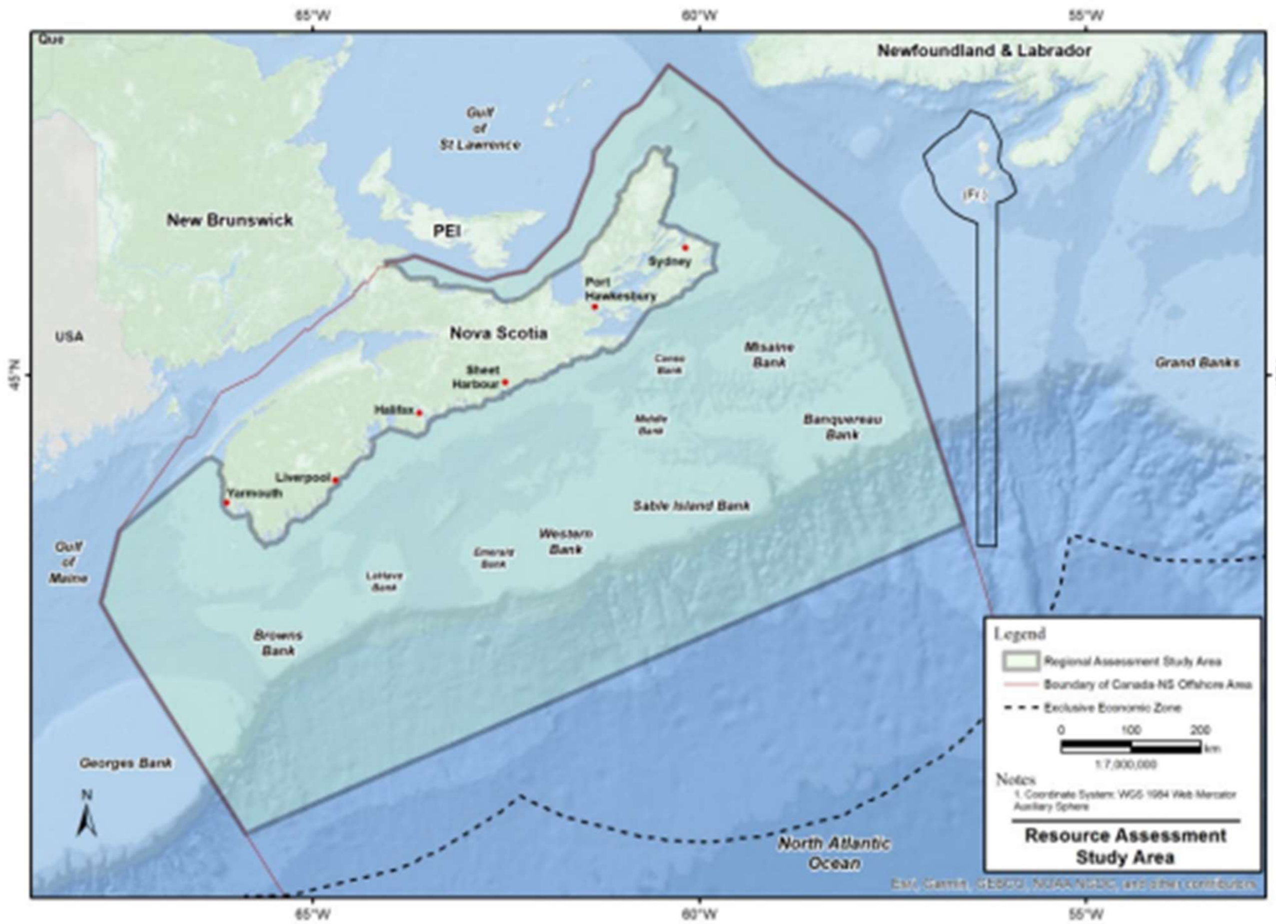


Figure 1. Regional Assessment Study Area

DMDE Engineering Limited (DMDE) has been commissioned by the RA Committee to carry out a study to determine the effects and benefits that might accrue to Nova Scotian ports from development of the OSW in the Study Area. To determine the benefits, this study involved the following tasks:

Task 1.0 – A review and description of the major port facilities in the province. Note that there are, in addition, many small craft harbours which do not have capacity to service the OSW industry.

Task 2.0 – Analysis of the identified ports to determine their capacity to service the OSW industry based on the following filters: ports that have capacity to handle the industry's requirements with some upgrading; ports that could handle the requirements with more significant upgrading; and ports where it is not practical to upgrade.

Task 3.0 – Discussion and development of a concept for the construction of new fit-for-purpose port facilities to serve the requirements of the OSW industry.

Task 4.0 – Determination of the benefits of OSW on the operations at each port and the services that port could supply including construction of elements, operations and maintenance of OSW farms.

Task 5.0 – Discussion of possible phased development scenarios for the build-out of supply chain requirements on the ports, including the potential effect of both the Nova Scotia and the US OSW supply chain requirements on Nova Scotian ports.

Task 6.0 – Identification and discussion of the assumptions of possible methods for OSW turbine construction. For fixed bottom, for example, three development options, namely monopile, gravity based and jackets, are considered; floating technology is considered as a separate option.

Task 7.0 – Based on Task 5.0, provision of a cumulative analysis of the requirements to determine the components that would be needed in Nova Scotia Ports by all identified sources, i.e., monopiles, transition pieces, nacelle, towers, blades, etc.

Task 8.0 – Development of high-level costs for port development and port operations.

Task 9.0 – Identification and discussion of ancillary factors associated with OSW requirements that could result in socio and economic benefits in Nova Scotia.

This study was undertaken to support the work being done by the RA Committee. It also complements work being done by Black Point Consulting to forecast the socio-economic consequences associated with the potential development of OSW in the Study Area.

The following Chapters of this Report discuss in more detail the results and conclusions from these tasks.

2. Methodology of Approach

2.1 Nova Scotia Ports Description

The following table provides a high-level description of the major ports in Nova Scotia. The table identifies the Port, provides a brief description of the port infrastructure, suggested upgrades to the port to service the offshore wind industry, and an evaluation of the state of readiness to service the industry.

Port	Existing Infrastructure	Upgrades to Infrastructure	State of Readiness
Atlantic Canada Bulk Terminal	The facility is a marginal dock on the east side of Sydney harbour. It was the former Sydney Steel dock. It was purchased in the early 2000s by Provincial Energy Ventures to be repurposed as a coal transshipment dock. It has been renamed as the Atlantic Canada Bulk Terminal. It is not fully utilized as a coal terminal and as such has capacity to service offshore wind. Currently monopiles are being offloaded and stored at this facility.	Current offloading used SPMT units, the monopiles were offloaded over the caisson portion of the dock, using structure steel bridging to spread the load on the dock. The offload with dock cranes will require the construction of a heavy lift pad on the dock.	This terminal is ready, currently is receiving monopiles and transition pieces. Recently it has been stated the dock will require reinforcing to handle large onshore cranes to offload large items such as monopiles and transition pieces.
Liverpool	The port is located on the former Bowater Mersey Pulp and Paper Mill. It is currently owned by Build Nova Scotia and now called the Port Mersey Commercial Port. It has a berth 152.2 metres in length and a 7.3 metre draft. The wharf has a storge shed that occupies a large portion of the dock surface.	This area had considerable marshalling area. For upgrade, it would need a new wharf built for purpose to handle offshore wind components including deeper draft and high wharf bearing capacity.	At this time, the port is not ready to receive large offshore wind components it does have capacity to receive by sea, smaller / lighter onshore wind components and has done so in the past.
Woodside Marine Facility	The port is owned by the Nova Scotia Government and administered by Invest Nova Scotia. The facility has two main berthing areas. The main Woodside Wharf is 230 metres in length and a secondary wharf, known as the Exxon Mobil Wharf, is 65 metres in length. The facility is a multi use marine facility servicing many clients.	The port facility has limited marshalling yard area, servicing the other tenants using the facility (Irving). There are conceptual plans to tie the two docks together creating a considerable more continuous dock space and more marshaling area.	Woodside has already received large offshore wind components such as monopiles and transition pieces. The monopiles were mostly ship to ship transfer due to the limited dock space with other tenants. Currently the docks are not available as they have been fully leased by Irving for the construction of caisson for a new shipbuilder dock in Halifax Harbour. The lease is for approximately 2 years, this time period would not affect

			the dock to service the offshore wind industry as it will not start before that.
Port of Sheet Harbour	The port of Sheet Harbour is an industrial port facility located 150 kms from Halifax. Sheet Harbour currently handles mostly bulk terminals. The main marginal wharf is 152.2 metres long with concrete caissons. It has a draft at the wharf face of 13.75 metres. It has large accessible marshalling yard.	Although there is a large marshalling area at the dock, a considerable amount is used for existing operations The dock can be expanded to the south with another fit for purpose berth for offshore wind components and with considerable backup marshalling land created.	The port continues to handle major offshore wind components. These consist of monopiles and transition pieces. It has shown it can handle these. The issue is with wood fibre operations, the new aggregate shipping business and the ship dismantling operations. Although it can handle the pieces, marshalling is limited in the amount it can handle at one time
Port of Sydney Marine Terminal	Main dock currently referred as a Cruise Ship dock. Does have other cargo from time to time, petroleum vessels, Coast Guard, etc. As the Liberty Dock is solely a cruise ship berth, could be used for ship-to-ship transshipment of OSW components.	Liberty Dock is new and not feasible to upgrade to OSW supply chain dock. Main dock needs repairs to side structure.	This terminal is currently not ready to receive major OSW components such as monopiles, transition pieces, etc. it could receive smaller pieces such as cables, anchors, etc. it could also be used for ship-to-ship transfer.
Novaporte Development	Currently the only infrastructure available is what is known as the Confident Disposal site area developed for this opportunity for harbour dredge material.	The upgrade would include development of a new wharf and terminal designed as a fit-for-purpose facility for the OSW industry. The opportunity exists to design and develop a graving dock (dry dock) at the site for the construction of floating OSW platforms.	This proposed development on the west side of Sydney Harbour has the majority of the infill completed for large laydown area. The permitting is in place and the conceptual engineering is currently in progress. The terminal could move into detail deign and construction quickly.
Sydport Industrial Park	Several wharfs at this facility from former Canadian Navy Base. Docks all constructed in early 1950s (75 years old), not suitable and need to be replaced.	New fit for purpose dock constructed for OSW marshalling yard and transshipment facility.	Sydport is currently not ready. The former navel base has marshalling area and services, but the docks are in poor state and need to be replaced in order to receive OSW supply chain.
International Coal Pier, Sydney	The International Coal Pier is owned by NSP and is used to import coal. It was in the past an export coal terminal.	This facility should become available in 5 years when coal requirements is	This pier is going to continue to be sued as a coal receiving pier for NSP coal fired generating stations. It will not

		complete. To convert, it would require removal of the ship loader and infill out to the individual dolphins and removal of a large portion of the elevated rail loop to get access to inside of the loop for storage.	be available until at least 2030 and would need renovations to become an OSW supply chain terminal.
Bearhead Hydrogen Facility, Bearhead, Nova Scotia	Bearhead is working on the development of a green hydrogen, green ammonia study. Currently they have a new wharf designed, but not built.	The new wharf would be designed for purpose to export green hydrogen and ammonia, with the dock equipment, it would not be suitable for OSW components.	This project is in development, although there is a major dock designed, this dock design is not suitable for OSW supply chain, a new built for purpose dock would have to be designed and built.
Statia Terminals Dock, Strait of Canso	The facility consists of two berths, a very large supertanker dock to accommodate the delivery of petroleum products from the largest vessels in the world and an inner berth to load out petroleum on small vessels. The wharf deck is completely full with piping and loading and offloading area.	To upgrade at this facility would require the construction of a new designed for purpose dock and backup storage land.	The two berths used at this terminal are oil offloading and loading and the docks are full with mechanical equipment. It could be used for ship-to-ship transfer but not likely with the current berth usage.
Pt. Tupper Marine Coal Terminal, Strait of Canso	The Pt. Tupper Marine Terminal is owned by NSP and it is used solely to import coal. It has a dolphin type dock, 500 metres offshore connected by a trestle that supports inhaul conveyor. The dock has no vehicle access. The coal storage that will become available is at a high elevation to related to sea level and difficult to access for OSW components.	Upgrades to this wharf are not considered to be feasible with 500 metres offshore, depth of 18 metres, infill not practical and on land elevation is too high above sea level to be practical.	Similar to the International Coal Pier, this terminal is being used for coal import until at least 2030. The terminal layout is not compatible for OSW supply chain. The wharf has capacity but it is 500 metres offshore and would need considerable modifications to services OSW supply chain. It could be used for ship-to-ship transfer.
Port Hawkesbury Paper	PHP has a dock that was constructed in the early 1960s. It is currently used to import Kaolin for the supercalender paper procedure. This is imported via a self-unloader to a receiving hopper and inhaul conveyor.	Designs are being prepared to rehabilitate this dock. It is believed these modifications are to address the age and deterioration of the dock and not a major upgrade in the size or capacity. The design would have to be	This although proposing a major upgrade, will not be compatible for OSW supply chain expect for ship-to-ship transfer.

		changed accommodate the OSW supply chain.	
McNally Marine Terminal, Port Hawkesbury Harbour	McNally currently operates their marine based in Port Hawkesbury harbour. They store their marine plants, work boats, cranes, etc. McNally has recently purchased the former Georgia Pacific Terminal adjacent to their site. The materials handling infrastructure has been removed, the dock which is a series of independent dolphins remains. It is late 1950s vintage.	The upgrade considered for this Port would be the building of a new wharf on the former Georgia Pacific site. It would involve a new dock and marshaling area to handle all the OSW wind component. An add on option would be to construct a graving dock (dry dock) to construct floating OSW platforms.	This location with the purchase of the former Georgia Pacific Terminal has obtained significant on shore land and water lot for design and construction of a built for purpose dock for OSW supply chain.
Mulgrave Marine Terminal	The existing structure has been in place for a long time. One portion is the old ferry terminal prior to the construction of the Canso Causeway. It has been upgraded over the years. It is currently in play for onshore wind components.	Currently to accommodate the onshore wind components. A baily bridge is required to access the highway from the wharf. The marshalling yard is limited, large offshore wind components would require substantial expansion to the dock. Currently the minor upgrades could handle smaller items such as anchors and chains. Could be a supply berth to service the OSW vessels.	This terminal is currently gearing up to service the onshore wind supply chain. It has limited space for major OSW components but can be ready for small components, i.e., cables, anchors, chains, etc. It could be used for ship-to-ship transfer and as a berth for supply vessels.
Melford Terminal	The Melford Terminal is a proposed port along the western shore of the Strait of Canso. The original development was for a container terminal which is still in play, but now a portion of the facility is being considered as a marshalling facility for OSW components.	The first phase is approximately 1000 ft and would be designed to fit for purpose for both OSW vessels and container vessels.	Similar to Novaporte, this is a proposed facility. At this time, permitting is in place, land is available, and conceptual design is in progress. It would be ready to start detail design and construction.
Digby Harbour	Digby Harbour is predominately a fishing port. The dock structures are those required for a small craft harbour and not suitable for handling either OSW	The upgrade would be to construct a new fit for purpose dock for the OSW supply chain. With Fundy tides, the	Currently this port is primarily a fishing port with a full berth usage. Also, the existing dock is a small craft harbour and not compatible with large OSW

	or ONS wind components because of their size, load bearing and draft. Also, it is totally used for fishing industry.	inner harbour is limited in draft. A new dock would have to be constructed in the outer harbour. Considering the terrain the new dock would be mostly infill and with the tides this would be a considerable amount of infill.	components. If berthage was available, it could be sued for supply vessels.
Yarmouth	The Port of Yarmouth has several docks for fishing along with the Ferry Terminal. None of the docks currently are suitable for servicing large OSW components. At the harbour entrance is Bunker Island. It is connected to the mainland via a causeway. It was, in the past, an oil terminal for Irving Oil vessels. The main port wharfs are actually past capacity for servicing the fishing industry.	The option here is to rehabilitate the Bunker Island to become a marshalling port for the OSW supply chain. Although there is a wharf on the island, access was not available. It is felt that considering its former use and age, it could not be used for OSW supply chain.	Again, this is mainly a fishing port with very high usage at the three docks, so much so that they require a fourth dock for fisheries. If berthage was made available, it could be used for supply vessels.
Shelburne Port	The existing infrastructure consists of a relatively long finger pier with a T-section at the head. Vessels can dock along the finger pier, mainly small fishing vessels. Large fishing vessels with deeper draft moor on the outside of the T-section.	It appears the T-section has the length and draft deep to accommodate OSW vessels. The T-section is at the end of the stern and does not have sufficient backup land to marshal the OSW wind components. There is a plan to infill along the western side of the finger pier back to the shoreline. The T-section will have to be analyzed and possibly reinforced to get the required bearing capacity for large OSW components.	The wharf could be used for large OSW components with the extension of the dock to handle both large fishing vessels and OSW vessels. Also, needs infill for marshalling yard, which is under study no in the conceptual phase.

In summary from the description tables, the following is considered:

The Atlantic Canada Bulk Terminal in Sydney, the Port of Sheet Harbour and the Woodside Multi-purpose Marine Facility in Halifax Harbour have all handled OSW components for the US markets, and each can be upgraded to handle the requirements of both the emerging Nova Scotia OSW industry and the US industry. Note, only monopiles and transition pieces will be handled for the US market.

Both Novaporte in Sydney and Melford Terminals in the Strait of Canso are large scale developments in early development. They both started as potential container terminals, but the proponents of both see the opportunity associated with the emerging OSW industry and are developing terminal designs dedicated to significant portions of each to service the OSW industry. At Novaporte the opportunity exists to establish a fit-for-purpose graving dock (dry dock) to construct floating OSW platforms. Although not as advanced, the Keweit Group (McNally Construction) has purchased the former Georgia Pacific shipping facility in Point Tupper on the Strait of Canso. There is considerable land and a water lot at this site which could be designed as a fit-for -purpose facility for the OSW industry incorporating a marshalling area, new wharf frontage and possibly a graving dock.

The wharf facilities in Shelburne, Liverpool, and Sydport have not handled the needs of the OSW industry; however, all three have significant infrastructure that could be considered, although the rebuilds necessary to accommodate the needs of the OSW industry would be significant.

The Sydney Marine Terminal and the Mulgrave Terminal have limited marshaling area and expansion, although possible, would be difficult. Mulgrave is moving to be a major marine facility for receiving and transhipping onshore wind components. Both terminals could receive storage and transhipment of smaller components, i.e., anchors and chains for the floating option and electrical cables.

Neither the Port of Digby nor Yarmouth have the infrastructure necessary to service the OSW industry. The infrastructure at these ports is 100 percent dedicated to the fishing industry, and both need more fishing vessel berthage. It is assumed, if expansion were to take place, it would be to accommodate growth in the fishing industry, which is a very valuable industry in the province.

Statia Terminals, the Port Hawkesbury Paper Wharf and the proposed new Hydrogen Plant Terminals will be dedicated ports with dock space, dedicated cargos, including gas and oil loading; the berth usage preludes any capacity to handle OSW components.

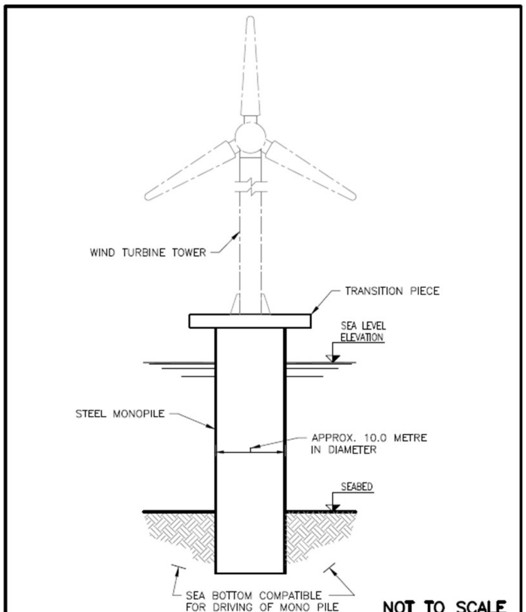
The existing Nova Scotia Power Coal Importing Terminals are both slated to be surplus by 2030. Both would need substantial modifications to convert from bulk handling terminals to OSW terminals. Since the terminals are required to continue to handle coal prior to their decommissioning, they would not be available until the mid 2030s so they are not considered in the potential costs for new marine facilities.

2.2 Description of Options for Offshore Turbines

In terms of offshore turbines, the assumption is that each offshore turbine will generate 15MW. The offshore turbines are basically similar, i.e., towers, nacelle and blades. Where the different options occur is in the base structure (foundations). The two main options for offshore turbines are fixed bottom and floating.

Fixed bottom structures (see sketches to the right) are described below,

Monopiles are large diameter steel pipe piles usually10 metres in diameter. The pile is driven from a specialized vessel into the seabed in waters of 35 to 60 metres, usually considered the practical depth of water. Monopiles, however, need the correct geophysical / geotechnical seabed conditions, namely a sandy, clay or glacial till bottom to allow the pile to be driven to the required depth for a solid foundation.

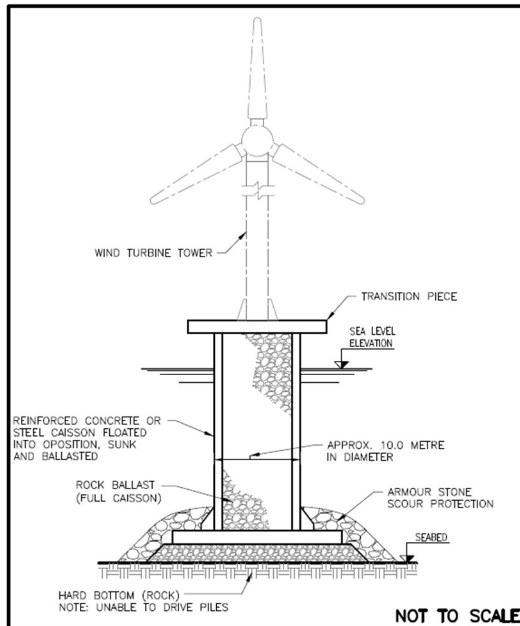


OFFSHORE WIND TURBINE, FIXED BOTTOM FOUNDATION, MONOPILE OPTION
FIG. No.1

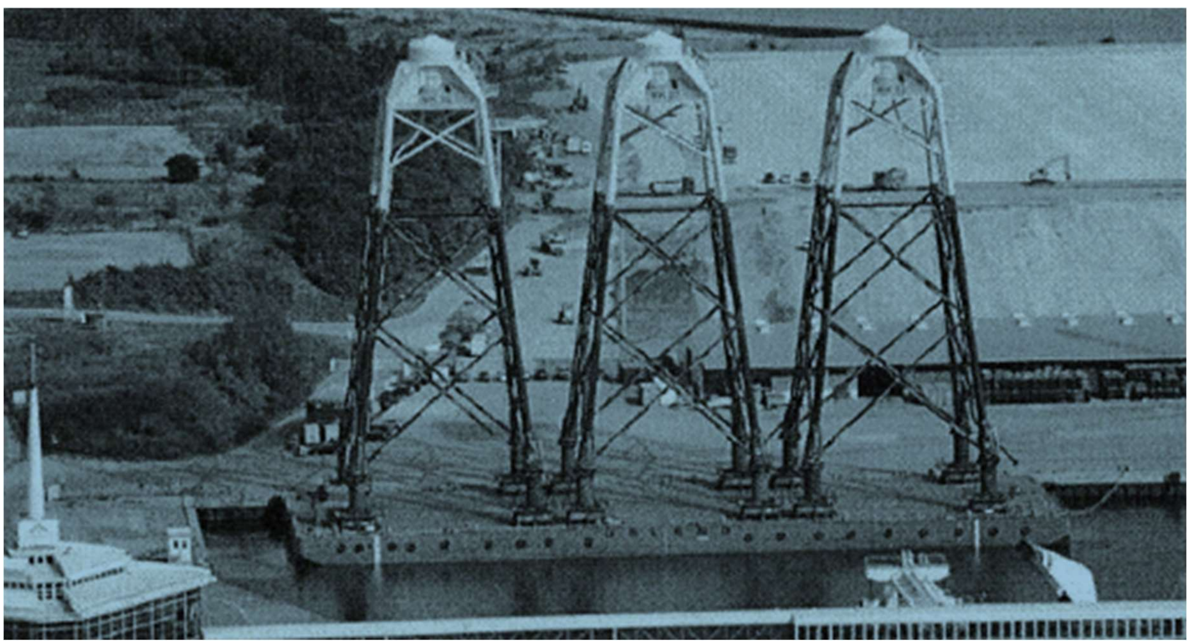
Gravity based structures (GBS) are large caisson type structures. They can be made of steel or concrete, but typically are made of reinforced concrete. They are considered fixed bottom as they bear on the seabed. They are generally fabricated at a dock, towed out to the seabed location and sunk in place. The initial sinking is with water, but once in place, it is ballasted with gravel aggregate. It is a mass structure relying on weight to provide resistance to environmental forces.

GBS are used where the sea bottom is too hard to drive monopiles, i.e., bedrock. It is estimated that 40-45 metres is the limiting water depth for their construction and placement.

Other fixed bottom options include jackets and suction bucket, see the sketch to the right. Both are less common than either the monopile or the GBS. Suction bottom is a relatively new approach and although interesting from a technical point of view, for the purposes of this study, not totally proven. Neither jackets nor suction bottom structures are considered in the analysis.

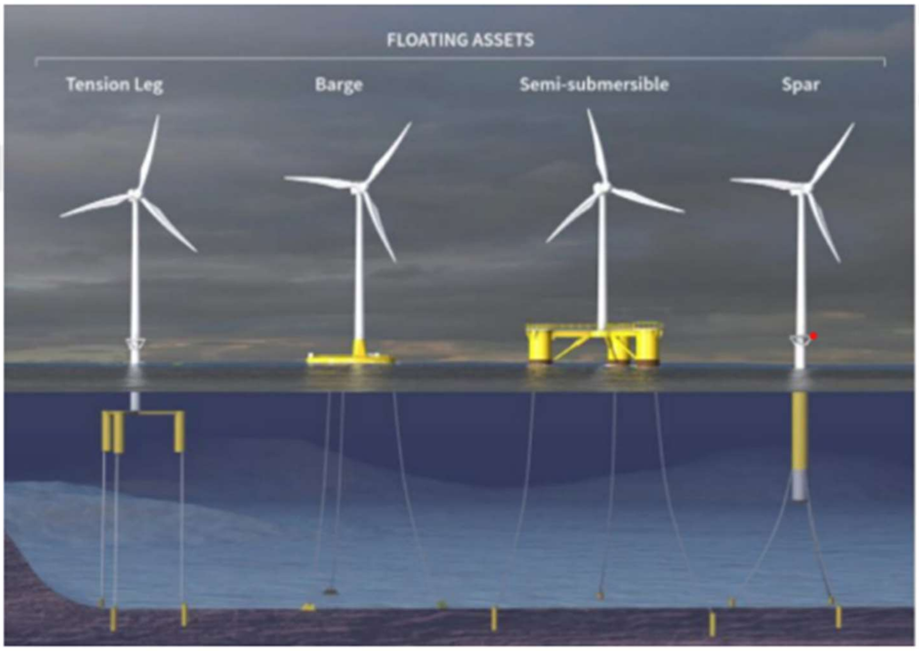


OFFSHORE WIND TURBINE, FIXED BOTTOM FOUNDATION, GRAVITY BASE CAISSON OPTION
FIG. No.2



Sample of Jacket

Floating techniques have a base or foundation for the wind turbine which is floating on the ocean surface. Floating technologies are used when water depths are such that fixed bottom options are not practical. The following figure shows alternative options for floating OSW turbines.



Typical Floating Substructure Types

Currently the most popular option for a floating installation appears to be the tension leg concept. In this option, three (3) large pontoons are constructed, either from reinforced concrete or structural steel. They are large, in the order of 10 metres x 10 metres cross section by 50 metres in length. The three pontoons are connected by spokes. The turbine is mounted at the centre and sunk with water to the water surface. The chains and anchors are attached. The water is then pumped out and the buoyant forces pull the chains tight, hence the name tension leg.

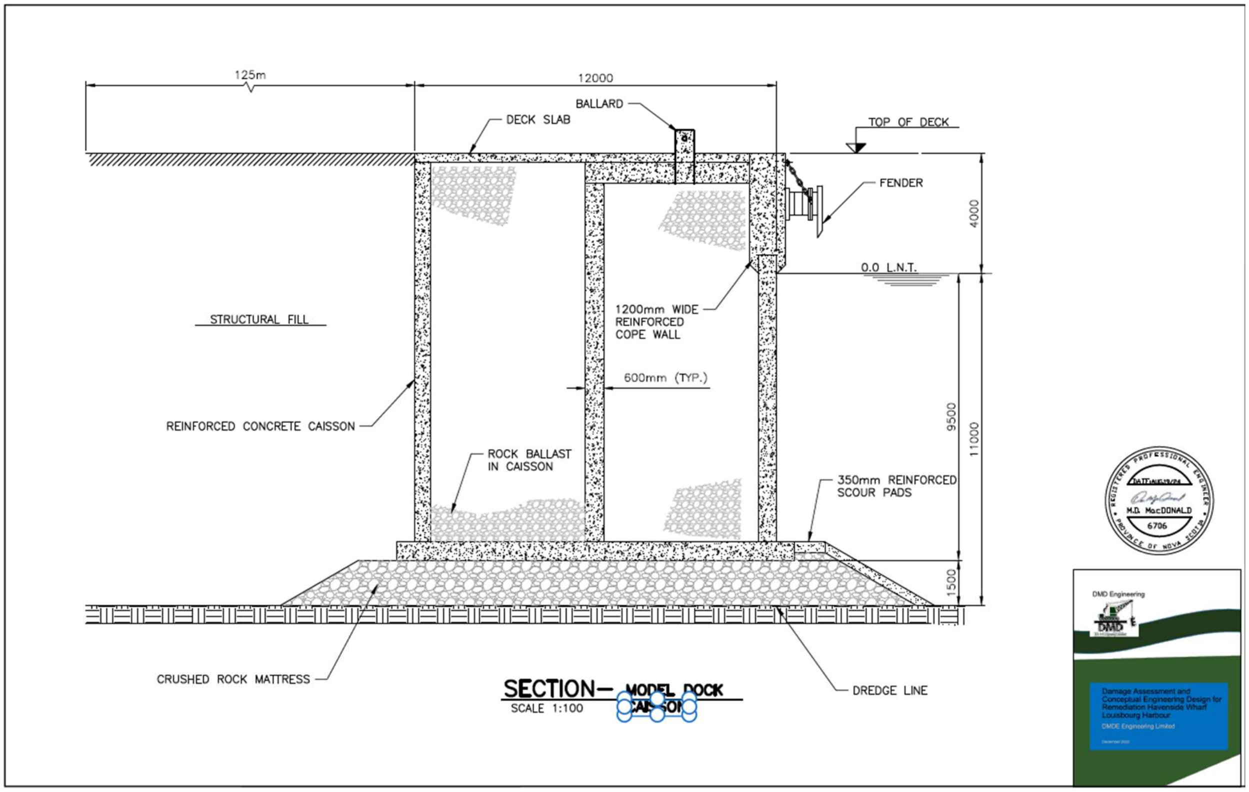
As stated, all three options are dependant on water depth and geophysical bottom conditions. Water depths can easily be determined, but geophysical conditions require significant investigation to determine the most appropriate type of turbine foundation. For each scenario, assumptions will be made as to what type of foundation and how many are required. The type of foundation assumed has a significant impact on the social-economic benefits that accrue. For example, monopiles are constructed offshore, delivered to a port for storage and then picked up by a specialized installation vessel. Assume the supply vessel carries 10 monopiles and 2 are offloaded per day, this would necessitate 5 days; loading out 1monopile at a time would be another10 days, resulting in a total of 15 days involving approximately 5 stevedores. This results in 75 person days of work. If you then include the handling of the other transition pieces, the result is 150 person days. The construction of 1 GBS caisson would involve 60 tradespersons, i.e., carpenters, labourers, and rebar tiers, 8 weeks or 56 days, for a total of 3,360 days per caisson. To build 10 GBS caissons would require 33,600 person days.

Type	Person Days
Monopile	150 person days
GSB Caisson	33,600 person days

This above is related just to activity at the port. There are significant benefits in terms of employment associated with the use of GBS. The latter because of their mass have to be constructed at a port in Nova Scotia, whereas monopiles are constructed offshore.

2.3 Model for Port Upgrade

This section presents a model design for an offshore supply chain port. The sketch shows the details of a concrete caisson wharf. The two most common types of wharf construction used in Nova Scotia are caisson and pile work.



Caisson construction is suited to hard bottom, either bedrock or hard till. In the past, caisson wharfs were generally more costly to construct than pile work, but with the cost escalation of steel piles over the past five years, the costs are relatively close. For this Report, the caisson wharf was selected as the model for pricing and determining economic benefits:

The elements of this model wharf include:

- Concrete caisson
- Reinforced concrete copewall
- Reinforced concrete deck
- Dredging of soft sediment
- Placement of crushed rock, levelling of mattress
- Scour protection
- Backfill

For estimating purposes, the following are the key dimensions used:

- Length 250 metres
- Caisson width 12 metres
- Caisson height 15 metres

- Backfill 100 metres for inside edge of caisson

The estimated capital cost of this model wharf is as follows:

Capital Estimate Model Wharf

Offshore Wind Supply Chain

Item	Description	Unit	Unit Price	Quantity	Total
1.0	Caisson including dredging & mattress	LS	$ 58,700,000.00	1	$ 58,700,000.00
2.0	Reinforced concrete copewall	Cu. Metre	$ 2,500.00	1,370	$ 3,425,000.00
3.0	Reinforced concrete deck	Cu. Metre	$ 2,000.00	900	$ 1,800,000.00
4.0	Scour protection	Cu. Metre	$ 2,000.00	411	$ 822,000.00
5.0	Fenders	Each	$ 75,000.00	20	$ 1,500,000.00
6.0	Bollards	Each	$ 100,000.00	8	$ 800,000.00
7.0	Backfill	Cu. Metre	$ 50.00	468,750	$ 23,437,500.00
8.0	Lighting	LS	$ 500,000.00	1	$ 500,000.00
				Sub total	$ 90,984,500.00
				Geotechnical 1%	$ 909,845.00
				Engineering 5%	$ 4,549,225.00
				Project and Construction Management 10%	$ 9,098,450.00
				Sub total	$ 105,542,020.00
				Contingency 20%	$ 21,108,404.00
				Total	$ 126,650,424.00

The unit price per metre of wharf equals $126,650,424 / 250 metres => 50,662 approximately $500,000 per lineal metre of new dock construction / metre.

*Unit prices for major items were supplied by McNally Construction (largest marine contractor in Atlantic Canada) and the author of this Report. The Author also developed the wharf concept based on 49 years of experience in the design and construction of major marine facilities.

The unit price of $500,000 per linear metre will be used to develop estimates of the costs of upgrades to existing wharfs and for new purpose-built wharfs.

The following is a high-level percentage split for projects of this type:

- Labour 50%
- Materials 35%
- Construction 15%

From discussions with Labour Union officials, the cost to put a tradesman on a construction project varies from $75/hr to $95/hr, depending on the contractor markup for profit and overhead. For this Report, the mean of $85/hr. is assumed.

For the model wharf design, this would breakdown as follows:

- Labour 50% x $90,000,000 => $45,000,000
- Materials 35% x $90,000,000 => $31,500,000

- Construction 15% x $90,000,000 => $13,500,000
- Manpower estimate = 45,000,000 = 529,412 person hours @ $85/hr = 66,176 person days.

2.4 Discussion on Select Ports

It should be understood that the ports that have been identified for possible use as handling OSW components are currently active within the province and as such cannot devote their full operations to the support the OSW industry. The following is a summary of the current state of some of these ports.

Atlantic Canada Bulk Terminal, Sydney Harbour – its primary operation is as a coal transshipment terminal. Coal is shipped from mines around the Great Lakes in lake vessels (approximately 30,000 DWT per vessel). The coal is stored at the marine terminal until there is sufficient to fill a cape sized vessel (180,000 DWT) for shipment overseas. Currently this facility is also handling offshore wind components, i.e., monopiles and transition pieces for offshore wind farms in the United States. They are received from Europe, offloaded, stored and reloaded on the installation vessels. The split between coal operations and OSW servicing at the terminal has not yet been defined. Assume 75% berth usage, which is the norm in the industry. Assume coal operations 30%, and 45% of berth usage dedicated to offshore wind components.

Mulgrave Marine Terminal – this port handles many different products including salt, bulk products and provides berthage for fishing and other vessels. The terminal has very limited marshalling space. Currently the Mulgrave Terminal is positioning to be a major port to handle onshore wind components. It is strategically located to service the projected wind farms to be developed in Guysborough, Pictou and East Halifax Counties. The 25-gigawatt onshore wind development is predicted to take place over the next 5 years (2025-2030). Five gigawatts of offshore wind development may occur through to 2035. Mulgrave Terminal could supply services, but with limited dockside marshalling space; it would most likely to handle cable reels, anchors and chains for floating installations.

Sheet Harbour – this port currently has several operations: there is a major operation involving the manufacturing and shipping of wood fibres, and a portion of the dock is equipped with a movable shiploader to convey the fibres onto vessels. There is also a demolition operation for vessels and offshore oil platforms. Recently Dexter has developed a quarry in proximity to the port and is shipping considerable quantities of crushed rock to the US. Sheet Harbour has handled monopiles and transhipment pieces for the US. It is becoming a busy wharf. Plans have been developed for its expansion. If implemented, the port could handle more work from the OSW industry.

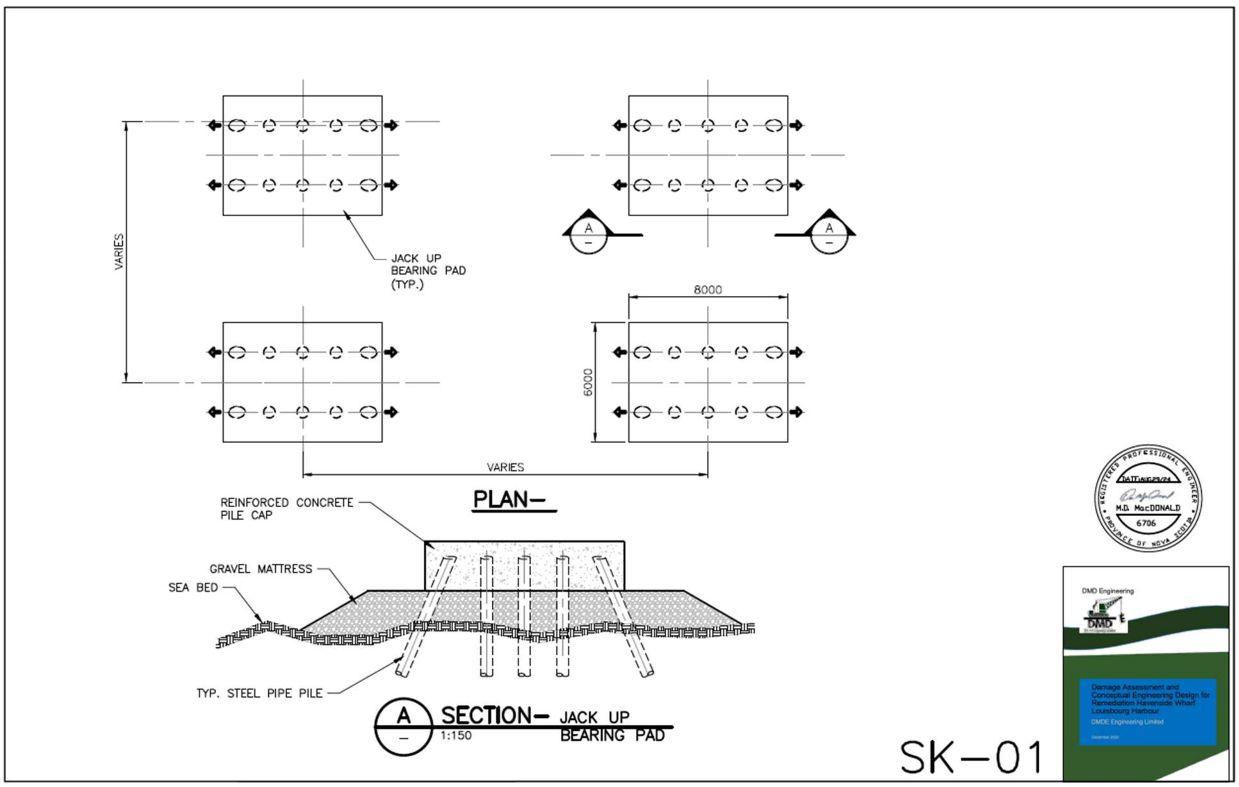
Woodside Marine is located in Dartmouth on the east side of Halifax Harbour. This facility was previously used as a service port for the offshore oil industry. More recently it has provided dockage for various cargos including projects for Irving Oil. Currently it is leased to the Dexter / McNally Venture to be the construction base for concrete caissons for the new Irving Dock in Halifax. It is estimated that it will be used for this for the next two years. It has in the past two years handled OSW components, monopiles and transition pieces, for US projects. The components did not come ashore: it was ship to ship transfer from the supply vessel to the installation vessel. There is limited marshalling area at this facility. Conceptual plans have been developed to expand the dock and marshalling area. If these are completed, it enhances the ability of this facility to handle large OSW components.

Shelburne – the wharf facility is located in the Town of Shelburne; there is a second facility in the County, formally an old Canadian Naval Base. The latter was not considered. The main business at the town dock is the accommodation of fishing vessels, including Clearwater’s large fishing vessels. The Town has plans to expand the facility. The dock has a long causeway from shore at the end of a T-section dock. It is understood that the plan is to infill the area along the west side of the causeway to create a marshalling area. To ensure continued service to the fishing industry, the T-section of the dock would have to be extended to accommodate OSW vessels.

Although the above are ports were selected for analysis, it does not mean that other ports could not be used. Port usage will depend on several factors including the preference of the wind farm developer, proximity to the wind farm site, available port infrastructure and cost. The above referenced ports have proximity to the potential wind farm areas, have port infrastructure, can be upgraded, and are located in different parts of the province, which should serve to better distribute local economic benefits. In addition, there will most likely be a requirement for one or more purpose-built port facilities to service the needs of the OSW industry; contenders include Novaporte in Sydney, Melford Terminals and McNally Lands, both in the Strait of Canso. These will be discussed below.

2.5 Discussion Offshore Maintenance and Operations

In addition to dock upgrades, each port facility considered should have the capacity to receive jack up vessels, which are used in the OSW industry as installation vessels. This would require the installation of four structured bearing pads on the seabed to support the jack up posts. These pads would be constructed of reinforced concrete piles driven into the seabed and a crushed rock levelling mattress installed (see the following sketch).



Jack up posts on vessels vary and the specification requirements would need to be confirmed prior to construction. The one illustrated has a greater area to have capacity to accommodate different configurations of jack-ups. The associated costs of are estimated as follows:

Item	Cost
Mobilization	$1,000,000
Piles	$800,000
Reinforced Concrete Pile Cap	$1,920,000

Crushed Rock Mattress	$25,000
Sub total	$3,745,000
Geotechnical 1%	$37,450.00
Engineering 5%	$187,250.00
Project and Construction Management	$374,500.0
Sub total	$4,344,200
Contingency 20%	$749,000.0
Total	$5,093,200.0

With respect to local economic benefits, all the materials, labour, and equipment could, except for the steel piles, be local to Nova Scotia. If one assumes that the supply of the piles to be 10% of the total cost, the amount contributing to local economic benefits would be as follows:

$5,093,200 x .09 = 4,583,880 ~4,600.000 for jack up pad. Estimate split for this type of work: 50% materials; 25% labour: $3,745,000 => 868,750 = 1250 person days; 25% construction.

3. Scenarios for Port Requirements

3.1 General

The RA Interim Report identified the following six (6) possible wind development locations:

- Sydney Bight
- Canso Bank
- Middle Bank
- Eastern Shore
- Sable Island Bank
- Emerald Bank

The locations are shown on the following figure.

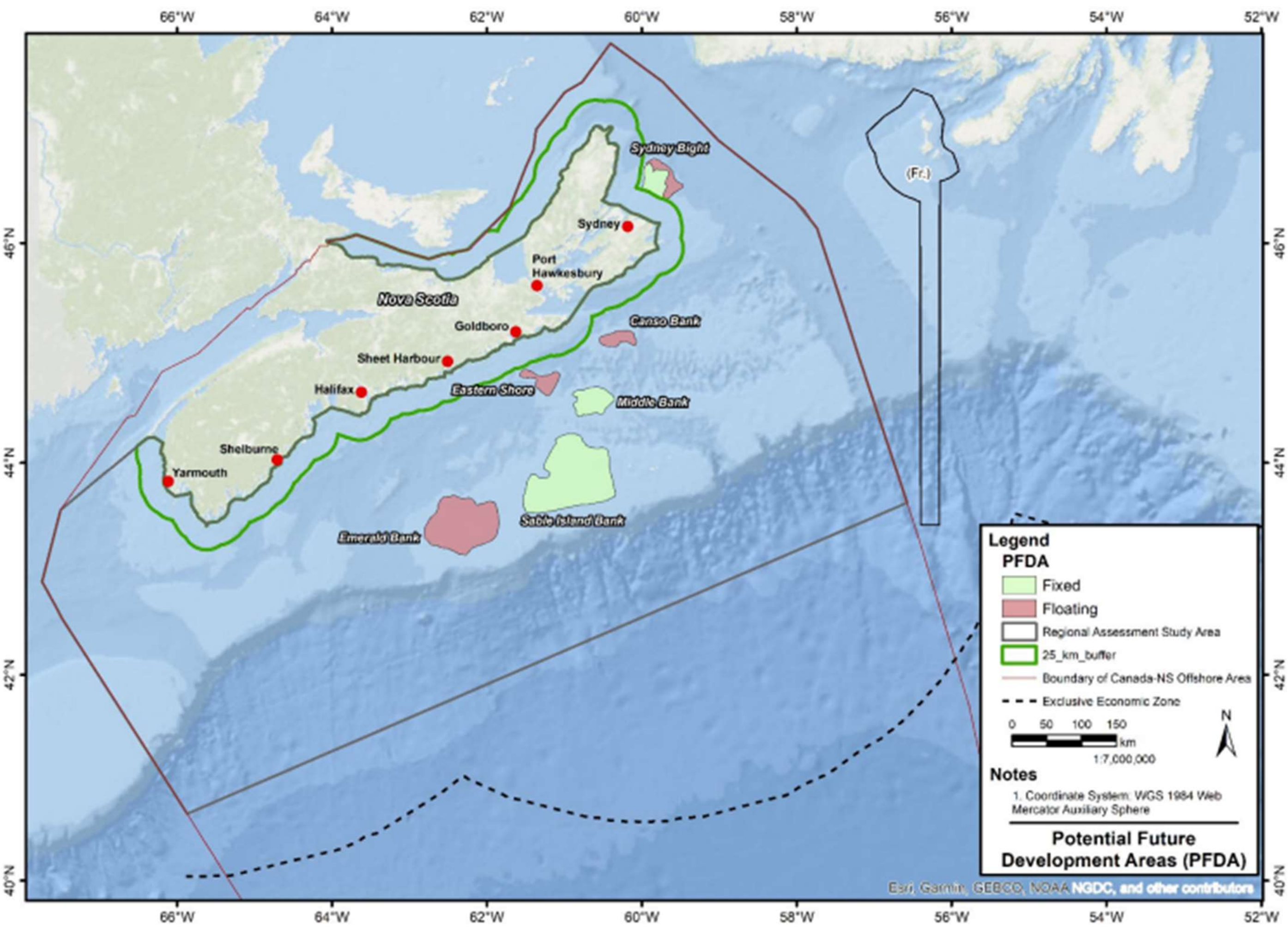


*Figure extracted from Regional Assessment Interim Report

3.2 Scenario Description

DMDE, in association with the RA Committee, selected three scenarios for this analysis; these are described below.

Socio-Economic SOW: Scenarios to Develop Costing for Economic Model

3.2.1 Scenario A

Stage1 – Location: Sydney Bight, five years from 2028 to 2032; power generation: 600MW; turbine type: floating.

Stage 2A – Location: Canso and Middle Bank, five years from 2031 to 2035; power generation: 1.5GW; turbine type: 70% monopile and 30% GBS.

Stage 2B – Location: Sable Island Bank, five from 2036 to 2040; power generation: 1.5GW; turbine type: monopile.

Stage 2C – Location: Sable Island Bank; five years from 2041 to 2045; power generation: 1.5GW; turbine type: monopile.

3.2.2 Scenario B

Stage 1 – Location: Eastern Shore and Sable Island Bank; five years from 2028 to 2032; power generation: 600MW; turbine type: floating.

Stage 2A – Location: Middle Bank and Sable Island Bank; five years from 2031 to 2035; power generation: 2.5GW; turbine type monopile.

Stage 2B – Location: Middle Bank and Sable Island Bank; five years from 2036 to 2040; power generation: 2.5GW; turbine type: monopile.

3.2.3 Scenario C

Stage 1 – Location: Eastern Shore and Canso Bank; five years from 2028 to 2032; power generation: 600MW; turbine type: floating.

Stage 2A – Location: Middle Bank and Sable Island Bank; five years from 2031 to 2035; power generation: 2.5GW; turbine type: monopile.

Stage 2B – Location: Middle Bank and Sable Island Bank; five years from 2036 to 2040; power generation: 2.5GW; turbine type: monopile.

Stage 3 – Location: Middle Bank, Sable Island Bank and Emerald Bank; ten years from 2041 to 2050; power generation and turbine type: 2.5GW monopile, 2.5GW GBS and 5.0GW floating.

This analysis does not propose to be definitive, but serves to highlight both the possibilities and the challenges involved in embracing the potential of offshore wind development.

4. Analysis of Port Requirements

4.1 General

For analysis, the following assumptions have been made:

- Fixed bottom monopile - each turbine will consist of nacelle, 3 blades, 4 tower sections, transition pieces and a monopile.
- Fixed bottom gravity-based structure – will consist of nacelle, 3 blades and four towers.
- Floating – will consist of nacelle, 3 blades, 4 tower sections, 4 prefabricated anchors and chains.
- Fixed bottom – consider up to water depths of 60 metres, past this depth, the floating will be considered.
- Turbines are assumed to be 15MW per unit.

4.2 Scenario A

4.2.1 Stage 1

The location for the first stage considered is Sydney Bight, as presented in the RA Interim Report. The installation is projected to generate 600MW of green power. The implementation time is five (5) years from 2028 to 2032 with an estimated completion rate of 20 percent per year. Due to the depth of the water, floating platforms are assumed.

Considering that most offshore wind developers want to be as close as possible to the development site, it is assumed that Sydney Harbour would be the preferred staging area for installations in Sydney Bight. The Atlantic Canada Bulk Terminal could accommodate the requirements of a floating development over a five-year period. Novaporte is currently working on the planning of a new marine terminal dedicated to the OSW industry. For this report, DMDE considers that both, or either, locations could be used to construct the required floating platforms.

4.2.2 Stage 2A

For this stage, the locations considered for the generation of 1.5 GW from 2031 to 2035 are Canso and Middle Bank. The anticipated implementation schedule is five (5) years with 20% to the total turbines developed per year, i.e., 20 turbines per year. The turbines constructed will be fixed bottom.

The closest ports to Canso and Middle Banks are Sydney and the Strait of Canso. To accommodate the proposed development schedule, a dedicated fit-for-purpose facility in required in both harbours. Novaporte in Sydney has already been identified; it is anticipated that it would have three berths: two for building floating platforms and one to receive the components (towers, nacelle, blades, etc.). From previous calculations, it will take 112 construction days per floating platform, which would be three platforms per year per berth, i.e., 6 platforms per year. To meet the requirement of 20 per year, four (4) additional floating platforms would have to be built in the Strait of Canso; this would also require a built-for-purpose terminal.

4.2.3 Stage 2B

The ports closest to Sable Island Bank are Sheet Harbour and the Strait of Canso. To generate 1.5 GW requires the construction of 20 turbines per year over a five-year period, i.e., from 2036 to 2040. With proximity to Sable Island, it is assumed that the seabed would be primarily sand and, given the water depth monopiles could be used. From the previous calculations, each monopile is estimated to require at days port time; each of the two ports identified can handle 8 monopiles per year which translates to 16 monopiles. The balance of four monopiles required could be handles at the Woodside Marine facility in Dartmouth.

4.2.4 Stage 2C

To generate a further 1.5 GW between 2040 and 2045 at Sable Island Bank, it is assumed that the ports used would be the same as used for Stage 2B.

4.3 Scenario B

4.3.1 Stage 1

For Stage 1 of this scenario, the Eastern Shore and Canso Bark are identified as accommodating 600MW of OSW generation between 2028 to 2032. Due to the water depth, this is considered a floating development.

The generation of 600 MW requires 40 turbines which translates to the construction of 8 turbines per year. The two berths at Novaporte could accommodate the construction of 3 turbines per year / per berth which equals 6 turbines per year. The additional 2 could be constructed in a new build facility in the Strait of Canso.

4.3.2 Stage 2A and 2B

The anticipated locations for both Stage 2A and 2B are Middle Bank and Sable Island Bank. At each stage, i.e., from 2031 to 2035 and from 2036 to 2040 2.5 GW of generation would be developed. Assuming suitable substrate, i.e., a sand bottom, it is assumed that all turbines would be monopiles. The generation of 2.5GW translates to a requirement for 167 turbines; 33 turbines per year with a construction time of 45 days per turbine, i.e., the handling and transshipment of 8 units per year at any one berth. This level of construction would require the dedication of at least 4 berths: the Atlantic Canada Bulk Terminal and Novaporte in Sydney, a new purpose-built facility in the Strait of Canso and facilities at Sheet Harbour.

From 2036 to 2040 the requirement for Stage 2B would be the same as the above. It would necessitate the continued use of berths at the Atlantic Canada Bulk Terminal and Novaporte in Sydney, at a new purpose-built facility in the Strait of Canso and at a berth in Sheet Harbour.

4.4 Scenario C

4.4.1 Stage 1

This stage considers the development of 600MW on Canso Bark and the Eastern Shore between 2028 and 2032. Due to the water depth, this is considered to require a floating development. The generation of 600MW requires 40 turbines which translates to the construction of 8 turbines per year. Novaporte with 2 berths could supply 6 per year; the remaining 2 could be constructed in the new build facility at the Strait of Canso.

4.4.2 Stage 2A and 2B

This stage of Scenario C involves the construction of 2.5 GW from 2031 to 2035 in Middle Bank and Sable Island Bank and again from 2036 to 2040. The analysis required is the same as that undertaken for

Stage 2A and 2B in Scenario B, i.e., the dedicated use of berths at the Atlantic Canada Bulk Terminal and Novaporte in Sydney, at a new purpose-built facility in the Strait of Canso and at a berth in Sheet Harbour.

4.4.3 Stage 3

This stage involves the development of 10 GW at Middle Bank, Sable Island Bank and Emerald Bank between 2041 and 2050. The generation of 10 GW requires 667 turbines to be constructed over 10 years. This is 66 units per year. As Middle Bank and Sable Island Bank require fixed installations, a spilt between the use of monopiles and gravity-based structures is assumed to be 50/50 as there is insufficient geophysical and geotechnical data available at this time to be more definitive. The stated construction time in port for a GBS structure is 56 days. It is assumed that the caisson would leave the dock face to go to wet storage, i.e., at anchor in the harbour until such time as it was towed to site. With respect to the estimate 45 days associated with monopile assembly, must of this time is accounted for with storage time in the port marshalling yard as the various components are being delivered and the scheduling and availability of the installation vessel are completed. During this time, the wharf would still be available for GBS construction. The split between monopiles and GBS structures is assumed to be 50/50 as there is insufficient geophysical and geotechnical data available at this time to be more definitive. The stated construction time in port for a GBS structure is 56 days. It is assumed that the caisson would leave the dock face and go to wet storage, i.e., at anchor in the harbour, until such time as it was towed to site. With respect to the estimated 45 days associated with monopile assembly, much of this time is accounted for by storage time in the port marshalling yard as the various components are being delivered and the scheduling and availability of the installation vessel; the wharf could still be available for GBS construction. All available berths would be fully engaged – if the labour was available! This with floating for Emerald Bank, would include Atlantic Canada Bulk Terminal, Novaporte, new Terminal in Strait of Canso, Mulgrave, Sheet Harbour, Woodside and Shelburne.

5. Estimated Costs and Economic Benefits

5.1 Capital Costs

This section presents the high-level capital cost estimates required to upgrade existing wharfs and to construct new purpose-built facilities.

The ports identified by the Scenario analysis in the previous Chapter include:

- Atlantic Canada Builk Terminal
- Novaporte Terminal
- New Terminal Strait of Canso (with the proposed Melford Terminals or a Terminal at the McNally Marine Base)
- Sheet Harbour
- Woodside, Dartmouth
- Shelburne, Town dock facilities

The high-level capital costs will include the following:

- Wharf costs
- Jack up pads
- 2 – 300-ton dock cranes (note, considering the long duration, it is considered ports will buy cranes, not rent)
- Soft costs including engineering and project management

5.1.1 Atlantic Canada Bulk Terminal

As previously mentioned, this terminal is currently handling large offshore wind components, monopiles and transition pieces. These have been offloaded using a stern offloading which is a Mediterranean style of offloading. There has been commentary that many of the shippers prefer parallel berthing using large cranes to offload. The existing dock is not strong enough to support large cranes, but it could be strengthened by reinforcing a section to install a crane lift pad. It is estimated that 60 metres of dock be reinforced for a crane pad.

Estimate

Item	Cost
60 metres of dock face @ 500,000 lineal metres	$30,000,000
Jack up pads	$5,000,000
2 x 300 tonne crawler cranes	$3,000,000
Total	$38,000,000

5.1.2 Novaporte Terminal

This proposed terminal is on the westside of Sydney Harbour. It was originally going to be a container terminal; the developer, however, has considered the development of a major offshore wind terminal. For this report, 500 metres of new wharf face is assumed.

Estimate

Item	Cost
500 metres of dock face @ 500,000 lineal metres	$250,000,000
Jack up pads (2 berths)	$10,000,000
4 x 300 tonne crawler cranes	$6,000,000
Total	$266,000,000

5.1.3 Strait of Canso

There are two options for new facilities in the Strait of Canso: the Melford Terminal, similarly to Novaporte, is planning to designate a section of their proposed container terminal to accommodate offshore wind components, or a new build at the McNally Terminal base.

Estimate

Item	Cost
500 metres of dock face @ 500,000 lineal metres	$250,000,000
Jack up pads (2 berths)	$10,000,000
4 x 300 tonne crawler cranes	$6,000,000
Total	$266,000,000

5.1.4 Sheet Harbour

This site is currently handling offshore wind components for the US market including monopiles and transition pieces. The port currently accommodates a wood fibre operation, a demolition operation for vessels and offshore wind platforms, and crushed rock aggregate shipping. The port requires a major upgrade to handle OSW components in the future. Conceptual plans show 306 metres of new upgrades to the dock.

Estimate

Item	Cost
306 metres of dock face @ 500,000 lineal metres	$153,000,000
2 Jack up pads	$10,000,000
2 x 300 tonne crawler cranes	$3,000,000
Total	$166,000,000

5.1.5 Woodside Terminal

This terminal in Halifax has two separate marginal wharfs with limited marshalling area. There are conceptual plans to connect these separate docks and infill with 100 metres of new wharf.

Estimate

Item	Cost
100 metres of dock face @ 500,000 lineal metres	$50,000,000
Jack up pads	$5,000,000
2 x 300 tonne crawler cranes	$3,000,000
Total	$58,000,000

5.1.6 Shelburne Town Wharf

This is a major fishing wharf servicing large trawlers. The port has a plan to upgrade the dock mainly by creating a large marshalling infill area to continue to accommodate the fishing industry and to introduce space to attract OSW activity. 100 metres of new dock face needs to be constructed.

Estimate

Item	Cost
Infill area	$35,000,000
100 metres of dock face @ 500,000 lineal metres	$50,000,000
Jack up pads	$5,000,000
2 x 300 tonne crawler cranes	$3,000,000
Total	$93,000,000

5.1.7 Summary of Capital Costs

Port	Capital Cost
Atlantic Canada Bulk Terminal	$38,000,000
Novaporte Terminal	$266,000,000
New Terminal Strait of Canso	$266,000,000
Sheet Harbour	$166,000,000
Woodside	$58,000,000
Shelburne	$93,000,000
Total	$887,000,000

Other smaller facilities such as the Sydney Marine Terminal, Mulgrave Marine Terminal, Liverpool, etc. could be upgraded to accommodate the handling of smaller items such as cable reels, anchors, chains, etc. along with hosting operation and maintenance vessels. Adding in an estimate for these smaller upgrades, we would involve an estimated total estimated capital cost of $1,000,000,000 (1 billion dollars).

Note: all costs are in 2024 Canadian dollars. The costs presented are direct costs; to meet the requirements for port upgrades, this work should be carried out over the next 15 years.

5.2 Port Costs for Handling Offshore Wind Components

5.2.1 General

The port operations considered are for the receiving, storage and the fabrication of offshore wind components. The estimates include the costs related to this and do not include the costs incurred when the turbine unit leaves the port for installation offshore. Since most, if not all, offshore installation vessels are not available in Nova Scotia, these costs are not included in the analysis. All costs estimated are presented in 2024 Canadian dollars with no escalation factor applied. Note, these are very high-level order of magnitude costs and must be treated as such. There remain many unknowns and much further work is necessary.

5.2.2 Monopiles

Monopiles, as previously stated, are deployed in water depths up to minus 60 metres and in areas compatible to driving into the seabed (not bedrock bottom). The monopiles are fabricated offshore and delivered to Nova Scotia where they are offloaded, stored and then reloaded onto installation vessels for placement in the offshore wind farms.

The monopile in general is the lowest contributor to the Nova Scotia economy. The piles are fabricated offshore and the only operations carried out in Nova Scotia is receiving at port, storing and reloading to installation vessels. As they have to be driven into the seabed, the other components can only be installed at sea after the piles are driven.

Estimate of Operation Costs – Monopiles

No.	Item	Cost
1.0	Mobilization, offloading of piles and moving to shipping area	$250,000
2.0	Storage (estimate 40 days)	$65,000
3.0	Berthage	$1,350
4.0	Offloading of other wind components (blades, tower, transition pieces, nacelle unit)	$120,000
5.0	Port personnel costs / pile	$8,500
6.0	Loading out of monopiles and other components similar to offloading	$120,000
7.0	Storage of other components (estimate 40 days)	$100,000
Sub total		$664,850
20% Contingency		$132,970
Total		~$800,000 per monopile

5.2.3 Gravity Based Structures (GBS)

Gravity based structures, for the purpose of this report, are assumed to be concrete caissons. Concrete caissons are constructed at a port. They are generally constructed using moveable concrete formwork known as slipforms. The caisson is slipformed up to height where it is determined it can float, the sinking barge is sunk, and the portion of the caisson is floated returning to the dock and slip-formed to completion. It is then towed to the offshore wind farm location, sunk in place with water and then ballasted with rock. The remainder of the components are installed at sea; the top has to remain open to place the rock ballast.

Estimate of Operation Costs – Gravity Based Structures

No.	Item	Cost
1.0	Concrete caisson	$20,800,000
2.0	Ballast and armour supplied and loaded on barge	$1,992,000
3.0	Offloading of other components, towers, transition pieces, blades and nacelle	$120,000
4.0	Reloading components	$120,000
5.0	Berthage costs	$6,975
6.0	Wharf space rental	$35,000
7.0	Port Personnel	$680,000
Sub total		$23,753,995
10% Contingency		$2,375,397
Total		~$26,000,000

5.2.4 Floating

For the Report it is assumed that in water greater in depth than 60 metres, the foundations for the wind turbines will be floating. It is also assumed that the entire floating turbine would be constructed at the port and towed to the installation site where it would be anchored. The system assumed for this Report is known as a tension leg system, constructed using three large structural steel pontoons connected together with the remainder of the components installed. Note, specialized steel for offshore materials costs is not used for economic benefits.

Estimate of Operation Costs – Floating

No.	Item	Cost
1.0	Fabrication and installation at dock (3 pontoons)	$35,200,000
2.0	Receiving storage at dock of offshore wind components	$120,000
3.0	Construction of total turbine	$6,000,000
4.0	Storage	$150,000
5.0	Berthing costs	$27,000
6.0	Offloading storage and reloading of anchors and chains	$100,000
7.0	Port authority's costs and project management	$340,000

Sub total	$41,937,000
10% Contingency	$4,193,700
Total	~$46,000,000

5.2.5 Summary of Costs for Each Scenario

From the scenario analysis presented in Chapter 4 of this Report, this analysis is applied to the unit costs developed in the preceding Chapter with the result being the economic benefits for each scenario. In summary they are as follows:

Type	Economic Benefit
Monopiles	$800,000 each unit
Gravity Based Structures	$26,000,000 each unit
Floating	$46,000,000 each unit

It must be noted that these are not absolute cost estimates for these options, it is the economic benefit cost realized by the Province of Nova Scotia.

Scenario A, Stage 1

Sydney Bight over the 5-year period 2028 to 2032: 20% installation per year to generate 600MW. Due to the depth of water, all units are considered floating. Assuming 15MW per turbine requires 40 turbines. Building 20% per year necessitates the construction of 8 turbines per year.

Year	Turbines	Unit Price	Total
2028	8	$46,000,000	$368,000,000
2029	8	$46,000,000	$368,000,000
2030	8	$46,000,000	$368,000,000
2031	8	$46,000,000	$368,000,000
2032	8	$46,000,000	$368,000,000

Scenario A, Stage 2A

Canso and Middle Bank over the5-year period 2031 to 2035; 20% installation per year to generate1.5GW. All units assumed to be fixed bottom with the following split: 70% monopiles and 30% gravity based. At 15MW per turbine, 100 turbines are required: 70 monopile and 30 gravity based. This translates to 14 monopiles per year and 6 GBS per year.

Year	Monopiles	Unit Price	Total
2031	14	$800,000	$11,200,000
2032	14	$800,000	$11,200,000
2033	14	$800,000	$11,200,000
2034	14	$800,000	$11,200,000
2035	14	$800,000	$11,200,000

Year	Gravity Based	Unit Price	Total
2031	6	$26,000,000	$156,000,000
2032	6	$26,000,000	$156,000,000
2033	6	$26,000,000	$156,000,000
2034	6	$26,000,000	$156,000,000
2035	6	$26,000,000	$156,000,000

Total per year Scenario A, Stage 2A

Year	Monopiles	Gravity Based	Total
2031	$11,200,000	$156,000,000	$167,200,000
2032	$11,200,000	$156,000,000	$167,200,000
2033	$11,200,000	$156,000,000	$167,200,000
2034	$11,200,000	$156,000,000	$167,200,000
2035	$11,200,000	$156,000,000	$167,200,000

Scenario A, Stage 2B

Sable Island Bank over the 5-year period 2036 to 2040: 20% installation per year. Assume fixed bottom monopiles. To generate 1.5 GW over 5 years with 15 MW turbines would require a total of 100 turbines; 20 turbines would have to be installed each year.

Year	Turbines	Unit Price	Total
2036	20	$800,000	$16,200,000
2037	20	$800,000	$16,200,000
2038	20	$800,000	$16,200,000
2039	20	$800,000	$16,200,000
2040	20	$800,000	$16,200,000

Scenario A, Stage 2C

Sable Island Bank over the 5-year period 2041 to 2045. 20% installation per year. Assume fixed bottom monopiles. To generate 1.5 GW over 5 years with 15 MW turbines would require a total of 100 turbines; 20 turbines would have to be installed each year.

Year	Turbines	Unit Price	Total
2041	20	$800,000	$16,200,000
2042	20	$800,000	$16,200,000
2043	20	$800,000	$16,200,000
2044	20	$800,000	$16,200,000

2045	20	$800,000	$16,200,000

Scenario B, Stage 1

Eastern Shore and Sable Island Bank over the 5-year period 2028 – 2032; 20% installation per year. Eastern Bank, Eastern Shore would be floating, Sable Island would be monopile. To generate 600 MW over 5 years with 15 MW turbines would require 40 turbines; 8 turbines would have to be installed each year.

Eastern Shore

Year	Turbines	Unit Price	Total
2028	4	$46,000,000	$184,000,000
2029	4	$46,000,000	$184,000,000
2030	4	$46,000,000	$184,000,000
2031	4	$46,000,000	$184,000,000
2032	4	$46,000,000	$184,000,000

Sable Island Bank

Year	Turbines	Unit Price	Total
2028	4	$800,000,000	$3,200,000,000
2029	4	$800,000,000	$3,200,000,000
2030	4	$800,000,000	$3,200,000,000
2031	4	$800,000,000	$3,200,000,000
2032	4	$800,000,000	$3,200,000,000

Total per year Scenario B, Stage 1

Year	Monopiles	Floating	Total
2028	$3,200,000	$184,000,000	$187,200,000
2029	$3,200,000	$184,000,000	$187,200,000
2030	$3,200,000	$184,000,000	$187,200,000
2031	$3,200,000	$184,000,000	$187,200,000
2032	$3,200,000	$184,000,000	$187,200,000

Scenario B, Stage 2A

Middle Bank and Sable Island Bank over the 5-year period 2031 to 2035; 20% installation per year. Assume use of fixed monopile because of proximity to Sable Island. To generate 2.5 GW over 5 years with 15 MW turbines requires the construction of 167 turbines; 33 turbines would have to be constructed each year.

Year	Turbines	Unit Price	Total
2031	33	$800,000	$26,400,000

2032	33	$800,000	$26,400,000
2033	33	$800,000	$26,400,000
2034	33	$800,000	$26,400,000
2035	33	$800,000	$26,400,000

Scenario B, Stage 2B

Middle Bank and Sable Island Bank over the 5-year period 2036 to 2040; 20% installation per year. Assume use of fixed monopiles because of proximity to Sable Island. To generate 2.5 GW with 15 MW turbines requires the construction of 167 turbines; 33 turbines would have to be constructed each year.

Year	Turbines	Unit Price	Total
2036	33	$800,000	$26,400,000
2037	33	$800,000	$26,400,000
2038	33	$800,000	$26,400,000
2039	33	$800,000	$26,400,000
2040	33	$800,000	$26,400,000

Scenario C, Stage 1

Eastern Shore and Canso Bank over the 5-year period 2028 to 2032; 20% installation per year. Assume use of floating because of water depth. To generate 600MW with 15 MW turbine requires the construction of 40 turbines; 8 turbines would have to be constructed each year.

Year	Turbines	Unit Price	Total
2028	8	$46,000,000	$368,000,000
2029	8	$46,000,000	$368,000,000
2030	8	$46,000,000	$368,000,000
2031	8	$46,000,000	$368,000,000
2032	8	$46,000,000	$368,000,000

Scenario C, Stage 2A

Middle Bank and Sable Island Bank over the 5-year period 2031 to 2035; 20% installation per year. Assume use of fixed monopiles because of proximity to Sable Island. To generate 2.5 GW with 15 MW turbines requires the construction of 167 turbines; 33 turbines would have to be constructed each year.

Year	Turbines	Unit Price	Total
2031	33	$800,000	$26,400,000
2032	33	$800,000	$26,400,000
2033	33	$800,000	$26,400,000
2034	33	$800,000	$26,400,000

2035	33	$800,000	$26,400,000

Scenario C, Stage 2B

Middle Bank and Sable Island Bank over the 5-year period 2036 to 2040; 20% installation per year. Assume use of fixed monopiles because of proximity to Sable Island, to generate 2.5 GW with 15 MW turbines require the construction of 167 turbines; 33 turbines would have to be constructed each year.

Year	Turbines	Unit Price	Total
2036	33	$800,000	$26,400,000
2037	33	$800,000	$26,400,000
2038	33	$800,000	$26,400,000
2039	33	$800,000	$26,400,000
2040	33	$800,000	$26,400,000

Scenario C, Stage 3

Middle Bank, Sable Island Bank and Emerald Bank over the 10-year period 2041 to 2050; 10% installation per year. Assume a split of 2.5 GW monopiles, 2.5 GW gravity-based structures and 5.0 GW floating structures for a total of 10 GW.

Monopile Turbines: 2,500MW / 15MW per turbine = 167 turbines. 10% per year = 17 turbines per year.

Year	Turbines	Unit Price	Total
2041	17	$800,000	$13,600,000
2042	17	$800,000	$13,600,000
2043	17	$800,000	$13,600,000
2044	17	$800,000	$13,600,000
2045	17	$800,000	$13,600,000
2046	17	$800,000	$13,600,000
2047	17	$800,000	$13,600,000
2048	17	$800,000	$13,600,000
2049	17	$800,000	$13,600,000
2050	17	$800,000	$13,600,000

Gravity Based Structure: 2,500MW / 15MW per turbine = 167 turbines. 10% per year = 17 turbines per year.

Year	Turbines	Unit Price	Total
2041	17	$26,000,000	$442,000,000
2042	17	$26,000,000	$442,000,000

2043	17	$26,000,000	$442,000,000
2044	17	$26,000,000	$442,000,000
2045	17	$26,000,000	$442,000,000
2046	17	$26,000,000	$442,000,000
2047	17	$26,000,000	$442,000,000
2048	17	$26,000,000	$442,000,000
2049	17	$26,000,000	$442,000,000
2050	17	$26,000,000	$442,000,000

Floating Turbines = 5 GW / 15 MW per turbine = 333 turbines. 10% per year = 33 turbines per year.

Year	**Turbines**	**Unit Price**	**Total**
2041	33	$46,000,000	$1,518,000,000
2042	33	$46,000,000	$1,518,000,000
2043	33	$46,000,000	$1,518,000,000
2044	33	$46,000,000	$1,518,000,000
2045	33	$46,000,000	$1,518,000,000
2046	33	$46,000,000	$1,518,000,000
2047	33	$46,000,000	$1,518,000,000
2048	33	$46,000,000	$1,518,000,000
2049	33	$46,000,000	$1,518,000,000
2050	33	$46,000,000	$1,518,000,000

Scenario C Summary

Year	**Monopiles**	**GBS**	**Floating**	**Total**
2041	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2042	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2043	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2044	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2045	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2046	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2047	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2048	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2049	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000
2050	$13,600,000	$442,000,000	$1,518,000,000	$1,973,600,000

5.2.6 Economic Benefits Summary Scenarios A, B and C

Year	Scenario A	Scenario B	Scenario C
2028	$368,000,000	$187,200,000	$368,000,000
2029	$368,000,000	$187,200,000	$368,000,000
2030	$368,000,000	$187,200,000	$368,000,000
2031	$535,200,000	$213,600,000	$394,400,000
2032	$535,200,000	$213,600,000	$394,400,000
2033	$167,200,000	$26,400,000	$26,400,000
2034	$167,200,000	$26,400,000	$26,400,000
2035	$167,200,000	$26,400,000	$26,400,000
2036	$16,200,000	$26,400,000	$1,973,600,000
2037	$16,200,000	$26,400,000	$1,973,600,000
2038	$16,200,000	$26,400,000	$1,973,600,000
2039	$16,200,000	$26,400,000	$1,973,600,000
2040	$16,200,000	$26,400,000	$1,973,600,000
2041	$16,200,000	$26,400,000	$1,973,600,000
2042	$16,200,000	$26,400,000	$1,973,600,000
2043	$16,200,000	$26,400,000	$1,973,600,000
2044	$16,200,000	$26,400,000	$1,973,600,000
2045	$16,200,000	$26,400,000	$1,973,600,000
2046	$16,200,000	$26,400,000	$1,973,600,000
2047	$16,200,000	$26,400,000	$1,973,600,000
2048	$16,200,000	$26,400,000	$1,973,600,000
2049	$16,200,000	$26,400,000	$1,973,600,000
2050	$16,200,000	$26,400,000	$1,973,600,000
Totals	$2,919,000,000	$1,464,0,000	$31,576,000,000

Notes:

Scenario C is very high as it is for 15.6 GW and relies on a lot of floating installations. Current estimates for the installation of 1 GW of offshore wind range from $4 billion US to $6 billion US; $5.3 billion CDN to $8 billion CDN. These costs do not seem unreasonable for local economic benefits.

Although not identifying total costs, DMDE offers this high-level analysis of the possible economic contribution this impact to the Nova Scotia economy.

Considering that the Nova Scotia government plans to license 5 GWs, this could yield up to a maximum of $40 billion in capital expenditure. A rule of thumb for associated engineering costs is from 7 to 10% of capital costs, in this case 8% is used.

0.8 x 40 billion = $320,000,000; average rate (blended, engineers/technologists) is $140/hr. Estimated engineering hrs $32,000,000 / $140/hr. would equal $2,285,714 hours. Over 10 years 228,571 engineering hours; assume 7.5 hours per day, this would equal 32,653 engineering days; assume 230 hrs/year, this would be 142 person hours of engineering.

As mentioned, once the licenses are released for bidding, major geotechnical and geophysical work will take place. This is difficult to quantify as it is unknown how developers will be competing for this work and how many will require studies. With the equipment and time required, it will be costly and will contribute to the economic benefit for Nova Scotia.

5.3 Operations and Maintenance

In terms of maintenance of the offshore wind farms, in discussions with operators in Europe, they indicate it was difficult to get firm estimates due to a number of variables:

- Over the period of 2028 to 2030, the amount of wind farms will increase, increasing maintenance; however, at this time there is no firm number on the amount of wind farms or the rate of increase.
- How the developers will carry out maintenance; for example, will each developer have their own or will several contract out to suppliers, which will affect costs.
- Maintenance requirements will increase with the age of the structures.
- In the beginning, the vessel will most likely be offshore vessels with offshore trained crews. This should change with time as people receive training in Nova Scotia.
- The North Atlantic Sea State, categorized as a very harsh environment, along with hurricane tracks is predicated to increase with global warming, this could increase the requirement for more repairs and maintenance.
- Quality of the components used could affect the amount of maintenance.

With this, it is hard to predict cost with these variables; however, it will over time provide economic benefits to Canada.

6. Ancillary Items

6.1 Education, Research and Labour Development

Doing the research for this study, it was revealed that because OSW development is relatively new, the industry requires extensive research to be carried out to support its technological development. In meeting with Dr. John Newhook, Dean of Engineering at Dalhousie University, DMDE discussed the potential impact of the OSW industry on the university. He presented the following costs based over a 20-year horizon:

- Five new professors
- Research funding $150,000 per year / per professor.
- 15 graduate students per year doing research
- Renovations to labs
- Support staff increase

Total estimated costs over 20 years equals $48.5 million.

6.2 Labour and Trades

In terms of the impact on labour and the trades, using the $53.3 billion figure associated with 5GW of development, assume half, or $26.65 billion, accrues to Nova Scotia. Taking a conservative approach, assume 25% of this figure is expended for labour, i.e., $6,625,000,000 in labour costs.

Assuming the cost of putting a tradesperson on the projects is paid at $85 per hour, this would generate 77,941,176 person hours. At 8 hours per day, this equates to 9,742,647 person days.

Person hours 77,941,175 hours per person days / 8 hours per day = 9,742,647 per person year. Years = 9,74,647 / 23 years = 18,382 person years.

7. Other Opportunities

As previously stated, the following are not necessarily directly related to port infrastructure and port operations, but were observed during the research undertaken in preparation of this report. DMDE therefore present these observations as they could have significant consequences for the overall socio-economic benefits to the province.

7.1 Fabrication of Monopiles

Most monopiles are currently manufactured offshore and shipped to Canada and the US. There could an opportunity for Nova Scotia to become a manufacture of monopiles for use in both Nova Scotia and Internationally. Monopiles are large, currently 10 metres in diameter and 150 metres in length. They are too large to transfer by road or rail. Since they are made to be installed offshore, they need to be manufactured dockside. Some possible locations in Nova Scotia include Cherubini Metal Fabrications in Halifax, which has the capacity to expand and have a dock that could be used to ship out, or Sydport in Sydney has the land and with ECMF manufacturers, recently purchased by MRL/Eskasoni Band, will reopen for metal fabrication. It has a dock, but it will require to be upgraded. In the Strait of Canso, new facilities could be built with water access, e.g., the McNally construction area could be a possible site.

7.2 Green Cement Supply

Currently there is an identified world shortage in cement, especially green cement. The latter is cement produced in kilns using green power, i.e., green electric and hydrogen. Dirty cement is that produced in coal fired kilns. Industries wishing to reduce their carbon footprint are looking to use green cement. Offshore wind producers in the US are starting to request that their offshore structures be constructed with green cement. The construction of a green cement plant has a high-capacity cost investment. The amount of green cement associated with offshore and onshore wind development in Nova Scotia may not warrant such investment; coupled with international requirements it could be feasible. Nova Scotia is well positioned to be a supplier of green cement, with large deposits of cement grade limestone, fly ash from years of coal fired electrical generations and well positioned ports.

7.3 Concrete Plants

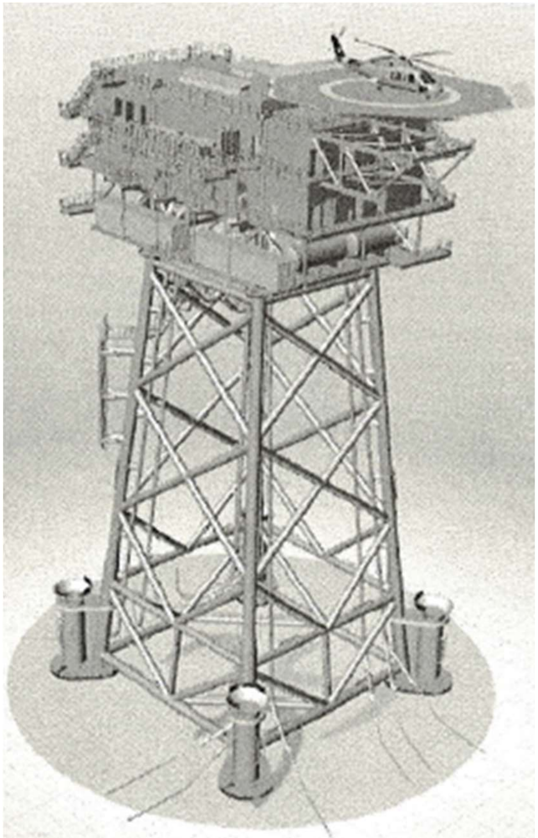
There are indications that Nova Scotia may be facing a shortage of concrete. The wind industry, i.e., in terms of both onshore foundations and gravity-based structures for offshore developments, plus other construction in Nova Scotia, the production of more concrete and more concrete plants. Concrete suppliers indicate a shortage of cement which is a problem; however, with increased demand more concrete plants will be required, possibly dockside.

7.4 Cable Manufacture

The offshore wind industry requires large amounts of electrical cable both for installation on the seabed and on land to facilitate upgrading transition facilities. Undersea cables are a specialty item and mostly fabricated in Asia, although Scotland has recently teamed up with Asian manufacturer to create fabrication in Scotland. Considering the projected lifespan of the offshore wind industry in Nova Scotia, it is not out of the question that Nova Scotia could have a cable manufacturing facility.

7.5 Offshore Substation

Depending on location and distance from shore, many of the offshore farms will need to be linked to an offshore substation (see the following figure).



It is most likely these substations would be fully fabricated overseas and shipped; however, again facilities could be developed in Nova Scotia to fabricate these structures. Possibly any facility built to manufacture monopiles could fabricate substations. The capital investment cost would have to be justified.

7.6 Vessel Construction

With the growth of the offshore wind industry worldwide, there is a major shortage in specialized vessels and more will have to be constructed. This could be a long shot for Nova Scotia industry, unless Irving Shipyards could be expanded to construct these vessels.

7.7 Accommodations

An important topic often raised is the current labour shortage, i.e., the need for more skilled labour. Any immigration to meet the demand will increase the demand for housing and accommodations and other services, especially in the more remote areas including Sheet Harbour, Shelburne, Liverpool, etc. Addressing these needs will again generate direct local economic development in Nova Scotia.

7.8 Other

Development Phase:

- Vessel operators will be required to support the resource and environmental characterization of the site
- Ecological Knowledge Study
- Visualization and engagement tools
- Geophysical and Geotechnical program operations
- Yard Development – heavy civil construction jobs, yard construction
- Wind Resources and Metocean studies
- Environmental Consultant(s)

Construction Phase:

- Construction of the land assets (e.g., road building, site levelling, power line installation, substation assembly, etc.)
- Anchor assembly and logistics.
- Assembly of the Floating structures (Welding, Mechanical and Electrical trades, Painting, Scaffold and Labour).
- Logistics services to move the large and small component.
- Yard security and yard support services.
- Installation of the cables, anchors and turbines offshore.
- Tugs and Vessels for towing Floaters to offshore and nearshore movements.

Operations Phase:

- Labour to support the ongoing operations and maintenance of turbines, mechanical, electrical and instrument
- Vessel support crews
- Wind farm operations
- Inspection contractors
- Asset Integrity
- Marine Base
- Logistics
- Environmental Monitoring
- Office Based team – PM, Procurement, Logistics, HSE/Regulatory.

As previously stated, the intent of this Report was to identify and define the economic benefits associated with port upgrades and associated activities that might accrue to Nova Scotia as a result of OSW development. This review has considered both the construction of additional ports for the OSW industry and work at the ports related to the industry. The preceding commentary was from information gathered when researching the port requirements. This work should be seen as a start to a more detailed examination of the opportunities, their feasibility and their contribution to the strategic planning for economic growth in the province.

8. Discussion on Impacts from Supplying Port Services for US Market

The US wind market, which is already underway and is predicted to install 50GW of offshore generation by 2050. Some Nova Scotia ports are already suppling services, e.g., Atlantic Canada Bulk Terminal in Sydney is handling monopiles and transition pieces; Sheet Harbour and Woodside are doing the same. The market is in a minor lull, but is predicted to start up again in 2027.

From 2027 to 2050, 23 years, and 50 GW with 15MW per turbine translates to the requirement for 3333 turbines. The prediction is that the US will handle all blades, towers and nacelle units, but due to the Jones Act, could require services from Nova Socia for monopiles and transition pieces.

Assume conservatively, Nova Scotia does 10% with one monopile and one transition piece each, this would calculate to 0.1 x 2(3333) 667 units. Over 23 years this would be 667 / 23 = 29 units per year.

Using the unit price calculated previously in this Report, this would equal $800,000 per unit. Economic benefits per year = $800,000 x 29 = $23,200,000 per year.

Total estimated economic benefit over 23 years (2028 to 2050) = $23,200,000 x 23 years = $533,600,000.

9. Impact of Onshore Wind on Ports

Recent predictions for the further generation of onshore wind in Nova Scotia onshore wind is are as follows:

- 1500MW for domestic supply
- 2000MW for new hydrogen production facilities.

The 2,000 MW assigned for the hydrogen facilities is based on the first two phases of each project being completed in the next five years. Consequently, DMDE takes into consideration only Phase 1 for each, i.e., 500 MW each.

It is assumed that the new onshore turbines will each have a capacity of 7MW. To generate 2,500MW, i.e., 1,500 MW for domestic supply plus 1,000 MW for each of the first phases of the hydrogen plants will require the construction of 357 turbines.

Each turbine will have 2 tower sections, 3 blades and a nacelle unit, which is 6 units to handle at receiving ports. Foundations would be poured in place (concrete). This means that 2,142 units need to be handled by Nova Scotia ports between 2025 to 2030.

In the scenario analysis presented in this study, offshore wind requirements for port space will start in 2028. If these timelines are realised, there could be competing demands for dock space in the period 2028-2029. This would place considerable pressure on available wharf space and marshalling capacity.

10. Summary and Conclusions

The analysis presented in this study indicates that the Nova Scotia offshore wind industry through its requirement for wharf footage and marshalling area could generate significant economic benefits to the province. This study's scope and focus on the ports served to identify the services that can be supplied to the offshore wind industry and the economic benefits that may accrue from these services.

The study, although not directly in the scope, but based on information obtained during the research, also references other potential opportunities that should be examined more fully in future assignments.

10.1 Required Port Upgrades

This study has indicted that existing ports in Nova Scotia do not have the capacity to completely service the requirements that may be generated by the offshore wind industry for wharf space and marshalling capacity. Considering the period from 2028 to 2050, the potential development era for offshore wind, planning for the necessary port upgrades and the development of purpose-build new facilities needs to start now, certainly no later than 2025. Planning, engineering and design, permitting and construction takes time.

10.2 Services for Offshore Wind Turbines at Port

The ports will be called on to provide the following:

- Handling marshalling and transhipment of monopiles, transition pieces, towers, blades and nacelle units.
- Construction of gravity-based structures, i.e., reinforced concrete caissons.
- Construction of complete offshore wind floating platforms, including receiving and storage of anchors and chains.
- Berthage and offshore vessel, both during construction and for operations and maintenance.
- Supply of aggregate for caisson ballasting and scour protection for both monopiles and caissons.

10.3 Estimated Economic Benefits

Scenario	Canadian dollars
Scenario A	$3,838,000,000
Scenario B	$2,140,000,000
Scenario C	$21,840,000,000

This is based on period 2028 to 2050.

10.4 Conclusions

From this analysis, DMDE draws the following conclusions:

- The offshore wind industry could be one of the largest industries in the history of the province.

- Economic benefits can be massive if strategically managed and planned properly.
- The existing ports with their current operations do not have the capacity to service the predicted scale of the offshore wind industry. Port upgrades and new port facilities are required.
- The US market presents an excellent opportunity to Nova Scotia ports.
- The spin off opportunities identified could generate billions of dollars in local economic benefits.
- For port development, time is of the essence, planning should start immediately and decisions made.

DMDE Engineering