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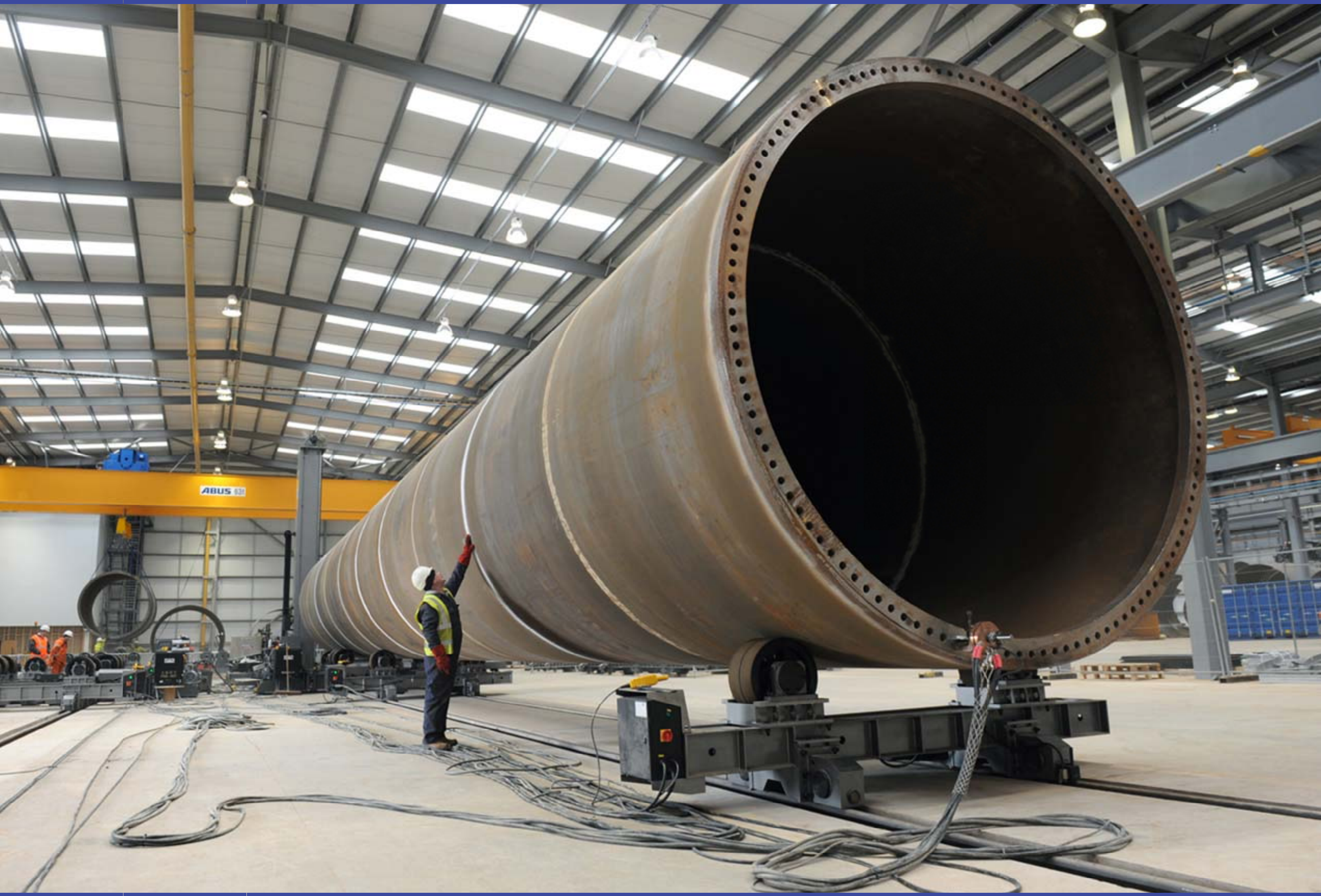
Virginia offshore wind port readiness evaluation



Report 3: High-impact investment opportunities

A report to the Virginia Department of Mines, Minerals and Energy

June 2015

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Document history

Revision	Purpose and description	Originated	Checked	Authorized	Date
1	For client	CJN	CLW	BAV	17 June 2015

BVG Associates

BVG Associates is a technical consultancy with expertise in wind and marine energy technologies. The team probably has the best independent knowledge of the supply chain and market for wind turbines in the UK. BVG Associates has over 150 person years experience in the wind industry, many of these being “hands on” with wind turbine manufacturers, leading RD&D, purchasing and production departments. BVG Associates has consistently delivered to customers in many areas of the wind energy sector.

Apex Companies

Apex delivers planning, engineering, environmental, and consulting services to clients across the United States and abroad. Apex has been at the forefront of port and site selection for the first purpose-build offshore wind support facility in the United Sates located in New Bedford, Massachusetts.

Offshore Design Engineering

ODE is an international engineering contractor to the offshore oil, gas and renewable energy markets providing comprehensive range of consultancy, engineering, project and construction management and O&M services. ODE have been involved in the development of some 400MW of offshore wind encompassing a majority of current UK project, plus providing considerable ongoing engineering and management support to North American and German markets.

Timmons group

Timmons group provides civil engineering, environmental, geotechnical, geospatial/GIS technology, landscape architecture and surveying services to a diverse client base. Timmons Group is headquartered in Richmond, Virginia.

Global Wind Network

GLWN is an international supply chain advisory group with a mission to increase the domestic content of North America’s wind energy installations, onshore and offshore. GLWN’s manufacturing engineering and wind supply chain expertise has been significantly leveraged these past two years with key projects specific to offshore wind component production for the U.S. Department of Energy, the National Renewable Energy Labs, Lawrence-Berkley Labs, the Massachusetts Clean Energy Center, and the New Bedford (MA) Economic Development Council.

Clarendon Hill Consulting

CHC provides inter-disciplinary consulting services in environmental and urban planning, port infrastructure and vessel analysis for the offshore wind industry and Geographical Information Systems (GIS), as well as general project management.

The views expressed in this report are those of BVG Associates and its partners. The content of this report does not necessarily reflect the views of Virginia DMME.

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Executive Summary

BVG Associates led a team commissioned by The Virginia Department of Mines, Minerals and Energy to evaluate ten Virginia ports for their readiness to accommodate seven different offshore wind manufacturing and construction activities:

- Blade manufacturing
- Generator manufacturing
- Nacelle assembly
- Tower manufacturing
- Foundation manufacturing
- Submarine cable manufacturing, and
- Construction staging.

The team also evaluated five Virginia commercial shipyards for their readiness to manufacture offshore substations.

This report is the third of three in this study, and presents high-impact investment opportunities to prepare Virginia ports for offshore wind manufacturing and construction staging. The other two reports present an evaluation of ten Virginia ports and the development of port utilization scenarios.

Potential for an offshore wind cluster

Virginia has strong potential for hosting offshore wind manufacturing and construction staging activity. Several ports have the right characteristics to enable manufacturing clusters. These clusters of activities could deliver important logistics benefits and economies of scale on infrastructure investment. They could also attract second- and third-tier suppliers to the region, especially for nacelle assembly.

Five distinct scenarios

Virginia's ports offer a lot of flexibility for locating offshore wind manufacturing and construction staging facilities. The five scenarios presented in this report are indicative of how Virginia's infrastructure can support offshore wind activity. The implementation cost of each scenario is summarised in Table 0.1. Each scenario incorporates all the facilities considered, but in a different geographical configuration.

Potential to create more than 1,500 direct jobs

Locating all seven of the manufacturing and construction staging activities in Virginia would generate more than 1,500 direct manufacturing jobs (sustained full time equivalent employees), many of which would be highly paid trade workers. The top two job creators – foundation manufacturing and blade manufacturing – could together generate more than 800 direct jobs. Figure 0.1 summarizes the direct job creation by activity and job classification. Additional indirect and induced labor would significantly increase the local benefit.

Investment opportunities

Upgrades to Portsmouth Marine Terminal, Newport News Marine Terminal, could position Virginia to be the premier offshore wind manufacturing and construction staging hub for the US East Coast. The port upgrades would cost from $11 million to $36 million and could be completed over a two- to four-year period, inclusive of permitting and engineering.

The demand from the offshore wind industry for upgraded port facilities is not yet strong enough to warrant major investments. The industry is proceeding at a pace where we expect port upgrades will need to have been completed by the end of 2022.

In the current market, and considering the position of competing ports, completing port upgrades ahead of commitment from inward investors is not recommended. Some preparatory work will be required, however, to enable final commitments from manufacturers to coincide with wind farm project financial investment decisions.

Competitor ports

As part of this study, we completed a regional port assessment and identified two ports that could be strong competitors with Virginia ports for attracting offshore wind manufacturing activities. Paulsboro, NJ is currently being upgraded to the specifications of the offshore wind industry and has sufficient space to create a cluster port with up to three manufacturing facilities. Sparrows Point (Baltimore), MD has space for multiple manufacturing activities, though the infrastructure needs upgrading.

Two additional ports could compete with Virginia ports to provide construction staging services for the northernmost part of Virginia's serviceable market. Those ports, already upgraded to offshore wind specifications, are New Bedford, MA and Quonset Point, RI. Neither port has sufficient space to attract a manufacturing supply chain.

Recommendations: A roadmap for Virginia

This report presents a series of recommendations that are tied to distinct signals from the offshore wind market. The timing is indicative and based on our expectations of how the market will develop over the next decade. Our market-driven recommendations are as follows.

<u>2015 – 2017</u>:
We recommend DMME to take the lead in making the case for offshore wind manufacturing and construction staging through a comprehensive socioeconomic analysis.

We recommend a coordinated effort on the part of DMME, the Virginia Economic Development Partnership (VEDP), and the Virginia Port Authority (VPA) to establish a preferred port utilization scenario, choosing from the five presented in this study.

We also recommend DMME ensures all the Virginia enabling bodies are presenting a clear, coordinated ports prospectus to offshore wind developers and manufacturers.

Finally, we recommend DMME monitors the progress at other regional ports, especially Paulsboro, NJ and Sparrows Point (Baltimore), MD and adjust the Virginia port strategy as needed.

2018 – 2020:
We recommend engaging with the developers and the supply chain to ensure the time line for port upgrades will enable and secure opportunities for domestic component supply. This timeline should also take account of superstructure development (including buildings, machinery and cranage) and the need to ramp-up production volumes over time.

We also recommend DMME and VPA remove barriers to upgrading the ports by completing permitting and engineering efforts.

Finally, we recommend providing information needed for due diligence on inward investment decisions, such as rental rates and timescales.

2021 – 2023:
We recommend securing inward investment from manufacturers and completing the port upgrades and, such that manufacturing can commence by the end of this period.

Table 0.1 Summary of port utilization scenarios and implementation costs.

Story	Scenario	Ports	Implementation cost
Super-port	1	Portsmouth Marine Terminal	$11 million to $25 million
Cluster ports	2	Portsmouth Marine Terminal Newport News Marine Terminal	$15 million to $36 million
Cluster ports	3	Portsmouth Marine Terminal Peck Marine Terminal	$14 million to $38 million
Cluster ports	4	Newport News Marine Terminal Peck Marine Terminal	$11 million to $33 million
Distributed port network	5	Portsmouth Marine Terminal Newport News Marine Terminal Peck Marine Terminal Virginia Renaissance Center	$20 million to $50 million

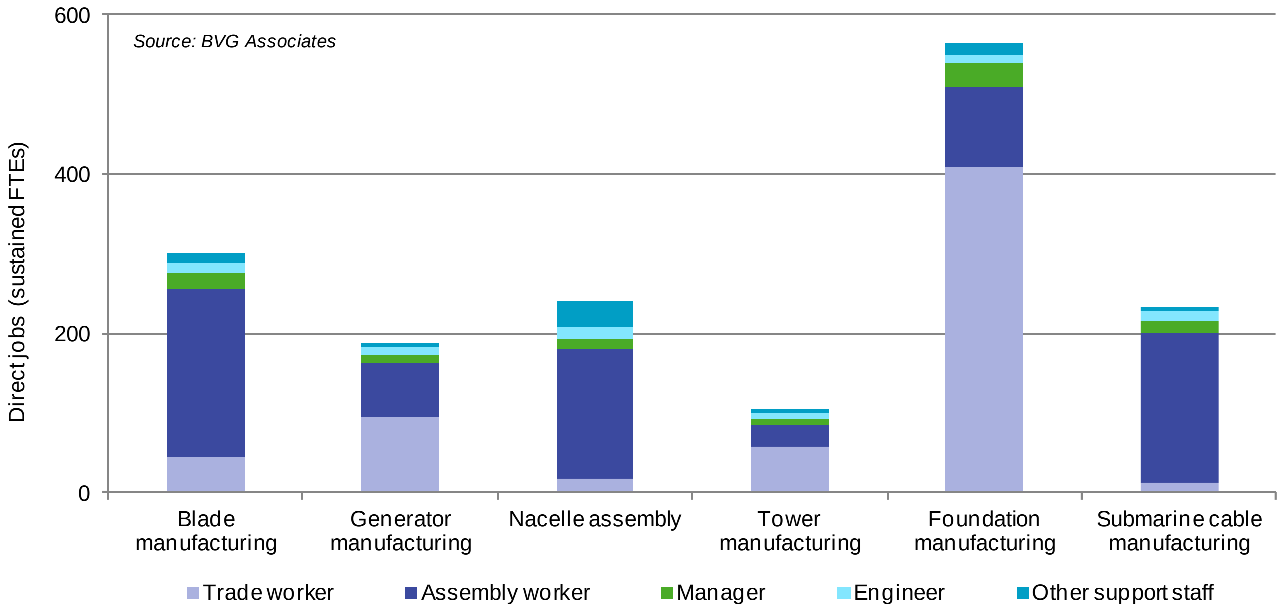

Figure 0.1 Summary of offshore wind manufacturing direct jobs by classification.

1. Introduction

The Commonwealth of Virginia Department of Mines, Minerals and Energy (DMME) commissioned BVG Associates (BVGA) and its partners to evaluate the readiness of Virginia's ports to support offshore wind farm manufacturing and construction.

This is the third of three reports setting out the results of the analysis. Table 1.1 lists these reports.

Table 1.1 Reports produced as part of the Virginia offshore wind port readiness evaluation study.

Number	Title
Report 1	An evaluation of 10 ports
Report 2	Port utilization scenarios for manufacturing and construction staging
Report 3	High-impact investment opportunities

Report 1

The first report presents an evaluation of 10 Virginia ports (see Figure 1.1) that have available or under-used waterfront infrastructure. We considered their use for seven distinct offshore wind activities:

- Blade manufacturing
- Generator manufacturing
- Nacelle assembly
- Tower manufacturing
- Foundation manufacturing and staging
- Submarine cable manufacturing, and
- Construction staging.

We concluded that the following five Virginia ports have the potential to accommodate one or more offshore wind activities:

- Portsmouth Marine Terminal
- Newport News Marine Terminal
- Peck Marine Terminal
- Virginia Renaissance Center (ex-Ford Plant), and
- BASF Portsmouth.

We also evaluated Virginia's commercial shipyards for their readiness to manufacture offshore substations. Our analysis identified four suitable shipyards, with no need for significant infrastructure upgrades.

Report 2

The second report presents offshore wind port utilization scenarios, with implementation costs, time lines and associated construction jobs, for the five aforementioned Virginia ports and characterizes the direct jobs that would be created.

Report 3

This third report combines the findings of the first two reports with further analysis that looks at the wider context of the offshore wind market in the US. We use these results to identify and prioritize the high-impact port infrastructure investment opportunities open to the Commonwealth of Virginia in the future.

Section 2 summarizes the findings of Report 1 to show the suitability of each of the 10 Virginia ports for each offshore wind activity. Section 3 details the cost and timescales for upgrading the most relevant sites and the associated creation of construction jobs.

Sections 4 and 5 summarize the findings of Report 2 to show how Virginia ports could accommodate offshore wind activities, showing implementation costs, time lines and associated construction and manufacturing job creation.

Section 6 provides a high-level analysis of the potential impact that the creation of a local supply chain could have on the cost of energy of offshore wind projects on the US east coast.

Section 7 summarizes the findings of our regional port assessment (provided in full as Appendix 1). This assessment considers where else a supply chain cluster might develop on the US east coast.

Section 8 uses all of the findings of this study to set out our assessment of the headline investment opportunities for the Commonwealth of Virginia.

Finally, Section 9 provides clear and concise recommendations for actions for DMME and the Commonwealth of Virginia in the next ten years, depending on the rate of progress of the offshore wind industry in the US.

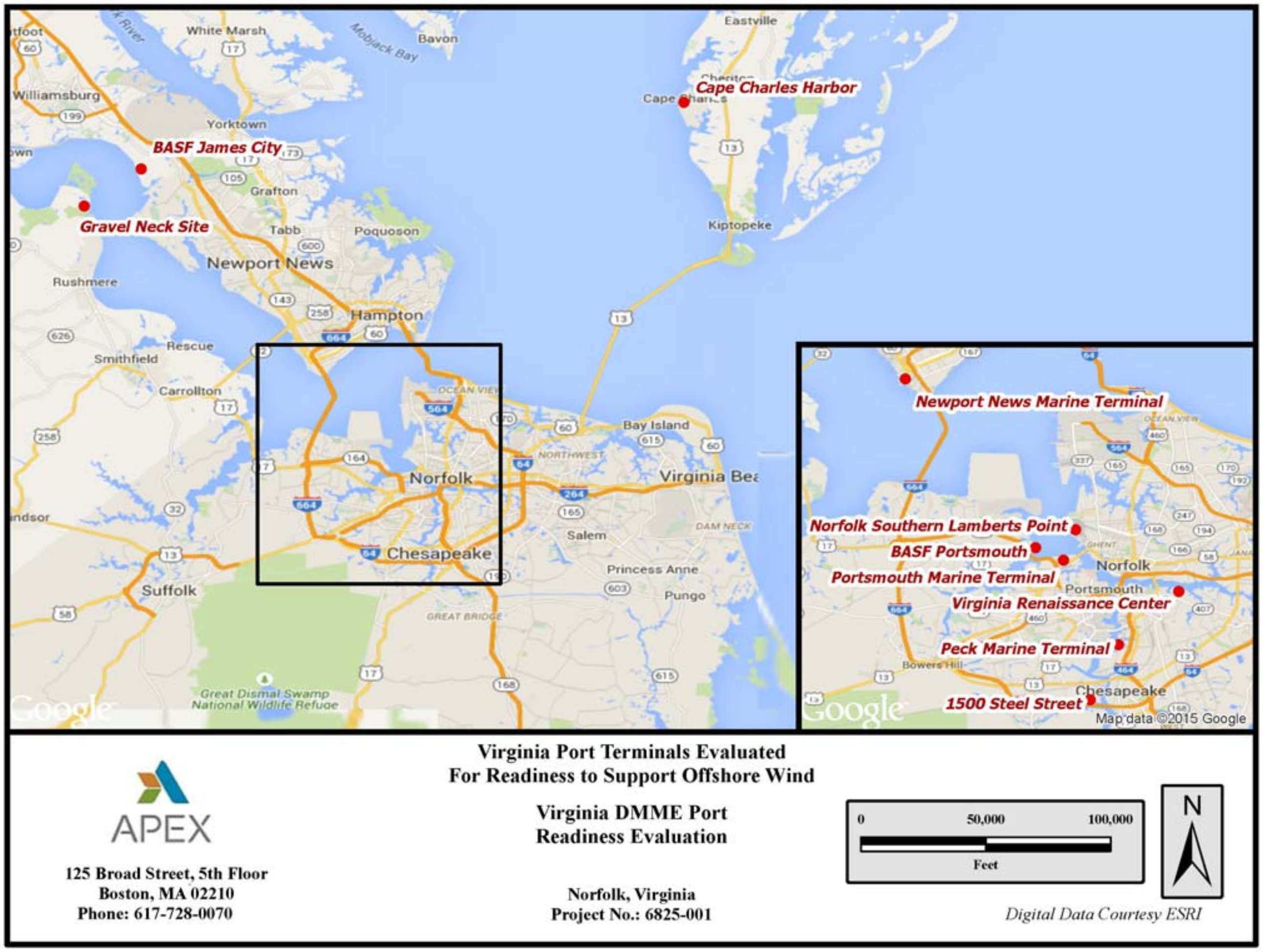

Figure 1.1 Map showing the ports considered in the evaluation.

2. Port evaluation

Report 1 presents the findings from our evaluation of 10 Virginia ports for readiness to support the following seven offshore wind activities:

- Blade manufacturing
- Generator manufacturing
- Nacelle assembly
- Tower manufacturing
- Foundation manufacturing
- Submarine cable manufacturing
- Construction staging

Table 2.2 summarizes the port evaluations. The readiness of each port was rated green, yellow, orange or red for each of the seven offshore wind activities. The ratings are defined in Table 2.1. Sites rated green or yellow have the highest level of readiness and were considered for additional implementation analysis (see Section 3). Sites rated orange have a lower readiness level and could be considered in a future study. Sites rated red have one or more hard constraints, such as inadequate space or low vessel clearance and hence currently we suggest that these should not be considered further unless a substantive change happens to requirements or the port infrastructure itself.

Norfolk Southern Lamberts Point was rated red for all activities for two reasons:

1. Its extensive rail infrastructure is generally incompatible with offshore wind activities, and
2. The port is thriving as a vessel-to-rail transshipment terminal, serving a critical function for the region.

Table 2.3 summarizes an evaluation of Virginia's commercial shipyard readiness to manufacture offshore substations.

Table 2.1 Grading of port suitability for each offshore wind activity.

Grade	Definition	Examples of constraint or work needed
Green	Site is suitable for the activity with minimal upgrade	• Resurfacing
Yellow	Site is suitable for the activity with significant upgrade	• Maintenance dredging • Targeted improvement dredging • Strengthening of existing waterside infrastructure • Defined-scope environmental remediation
Orange	Site is suitable for the activity with major upgrade	• New waterside infrastructure • Extensive improvement dredging • Full green-field development
Red	Site is unsuitable for the activity	• Air draft limitation • Insufficient space • Water depth (dredging disallowed or impractical)

Table 2.2 Summary evaluation of the ports.

Green = Site is suitable with few or no upgrades
Yellow = Site is suitable with upgrades
Orange = Site is suitable with major improvements
Red = Site is unsuitable
See Table 2.1 for rating definitions

	Portsmouth Marine Terminal	Newport News Marine Terminal	Cape Charles Harbor	Norfolk Southern Lamberts Point	Peck Marine Terminal	BASF James City	Gravel Neck	Virginia Renaissance Center	Steel Street Chesapeake	BASF Portsmouth
Blade manufacturing	Y	Y	O	R	Y	O	O	Y	O	Y
Generator manufacturing	Y	Y	O	R	Y	O	O	O	O	Y
Nacelle assembly	Y	Y	O	R	Y	O	O	R	O	Y
Tower manufacturing	Y	Y	O	R	Y	O	O	R	O	Y
Foundation manufacturing	Y	Y	O	R	R	R	R	R	R	Y
Submarine cable manufacturing	G	G	O	R	G	O	O	G	O	G
Construction staging	Y	Y	R	R	R	R	R	R	R	Y

Table 2.3 Evaluation of commercial shipbuilding capabilities for self-installing and conventional substation manufacturing.

Shipyard parameter	Optimal requirement	BAE Systems	Colonna's Shipyard	General Dynamics NASSCO	Marine Hydraulics International	Newport News Shipbuilding
Number of dry docks	1	2	2	1	0	4
Length (m)	50	1: 290 2: 174	1: 189 2: 70	229	-	1:198 2: 263 3: 217 4: 183
Beam (m)	50	1: 49 2: 31	1: 26 2: 21	37	-	1: 28 2: 35 3: 76 4: 43
Draft (m)	3.5	1: 18.2 2: 18.2	1: 9.1 2: 5.2	-	-	1: 10.1 2: 9.5 3: 10.1 4: 13.1
Evaluation for self-installing substation manufacturing		Dry dock 1 is suitable, depending on substation design	Insufficient beam	Insufficient beam	No dry dock	Dry dock 3 is suitable Dry dock 4 is suitable, depending on substation design
Evaluation for conventional substation manufacturing		✓	✓	✓	✓	✓

3. Implementation analysis

The analysis in Report 1 indicates five Virginia ports have a relatively high port readiness level for at least one offshore wind activity. The five ports are:

- Portsmouth Marine Terminal (PMT)
- Newport News Marine Terminal (NNMT)
- Peck Marine Terminal (Peck)
- Virginia Renaissance Center (VRC), and
- BASF Portsmouth (BASF).

Table 3.1 summarizes the implementation costs, time lines and associated construction jobs for upgrading each of the five ports for each of the activities.

The activities requiring the most extensive upgrades are construction staging, nacelle assembly, and tower and foundation manufacturing. These activities require ground and quay strengthening. Generator and blade manufacturing requires less extensive upgrades due to the lower ground strength requirements.

VRC has some of the lowest implementation costs, but can only accommodate blade and submarine cable manufacturing due to navigation restrictions. Peck could accommodate a small cluster of facilities, with implementation costs falling in the middle of the range compared to the other ports. PMT and NNMT have similar implementation profiles. Their implementation costs are the highest and they offer the most flexibility, as they are able to accommodate three or more activities.

BASF requires extensive dredging and new waterside infrastructure to accommodate offshore wind activities. Upgrading this port could be considered if port capacity in Virginia is not expected to meet demand. Otherwise, it is more cost effective to upgrade the other ports discussed.

Table 3.1 Implementation summary for five Virginia ports. The grey cells indicate an activity not suitable at the port. $$ = implementation cost; [calendar icon] = Time line; [person icon] = construction jobs, measured in full-time equivalents for one year (FTE-years)

	Portsmouth Marine Terminal	Newport News Marine Terminal	Peck Marine Terminal	Virginia Renaissance Center	BASF Portsmouth
Blade manufacturing	**$$:** $3.0 million-$10.8 million : 23 months : 15.2 FTE-years	**$$:** $2.9 million-$7.9 million : 15 months : 10.6 FTE-years	**$$:** $2.4 million-$8.7million : 7 months : 2.5 FTE-years	**$$:** $1 million-$5 million : 2 months : 1.6 FTE-years	**$$:** $13.3 million-$37.2 million : 3.5 years : 14.5 FTE-years
Generator manufacturing	**$$:** $3.0 million-$10.8 million : 23 months : 15.2 FTE-years	**$$:** $2.9 million-$7.9 million : 15 months : 10.6 FTE-years	**$$:** $1.3 million-$7.2 million : 6 months : 0.7 FTE-years		**$$:** $9.9 million-$32 million : 3 years : 12.8 FTE-years
Nacelle assembly	**$$:** $4.7 million-$16.5 million : 2.5 years : 25.2 FTE-years	**$$:** $4.5 million-$12.1 million : 2.5 years : 16.7 FTE-years	**$$:** $2.7 million to $13.8 million : 12 months : 4.2 FTE-years		**$$:** $13.9 million to $37.9 million : 3.5 years : 14.8 FTE-years
Tower manufacturing	**$$:** $5.9 million-$18.9 million : 2.5 years : 27.4 FTE-years	**$$:** $5.7 million-$14.5 million : 20 months : 18.9 FTE-years	**$$:** $5.1 million to $6.8 million : 4 months : 1.4 FTE-years		**$$:** $13.9 million to $44.7 million : 4 years : 16.3 FTE-years
Foundation manufacturing	**$$:** $5.4 million to $12.5 million : 25 months : 19.2 FTE-years	**$$:** $5.3 million to $13.8 million : 19 months : 17.6 FTE-years			**$$:** $9.3 million to $31.8 million : 2.5 years : 12.4 FTE-years
Submarine cable manufacturing	No upgrades required	No upgrades required	**$$:** $900,000 to $1.3 million : 1 month : 0.5 FTE-years	**$$:** $900,000 to $1.3 million : 1 month : 0.5 FTE-years	**$$:** $12.5 million to $38.9 million : 2.5 years : 14.7 FTE-years
Substation manufacturing	*Substation manufacturing readiness was evaluated at commercial shipyards. No upgrades are required.*				
Construction staging	**$$:** $7.3 million to $17.3 million : 2.5 years : 27.3 FTE-years	**$$:** $7.1 million to $14.4 million : 2.5 years : 21.6 FTE-years			**$$:** $13.5 million to $38.9 million : 3.5 years : 14.7 FTE-years

4. Port utilization scenarios

In Report 2, we presented port utilization scenarios for offshore wind manufacturing and construction staging activities in Virginia.

There are logistical benefits from the co-location of activities and we developed three “stories” which represent different degrees of co-location:

- **Super-port,** where all the primary offshore wind activities are co-located a single port
- **Cluster ports,** where multiple activities are co-located in two ports, and
- **Distributed port network,** where activities are spread across three or more ports so that each location hosts no more than three activities.

For each story, we devised one or more scenarios in which all seven offshore wind activities take place in Virginia ports.

Port development stages

Table 4.1 summarizes our assumptions about the expected stages of port development. The time line can be accelerated or delayed, depending on the pace of offshore wind market development. The dates therefore are indicative.

We expect the first mover to be construction staging, as a port location near a wind farm project has a strong cost benefit. The market trigger would be a project, or series of projects, having a combined capacity of at least 500MW.

We expect blade and towering manufacturing to be the first followers, with manufacturing investments triggered by an unmet demand for 500MW worth of components per year, with visibility of demand for approximately five years.

We expect generator manufacturing and nacelle assembly to be second followers, as they require a larger and more stable market demand than the first followers to trigger an investment in new manufacturing facilities.

Foundation and submarine cable manufacturing could lead or lag the other activities by several years, as they are dependent on the global (and not necessarily the local) market demand.

Table 4.1 Port development stages.

Port development stages	Offshore wind activity	Market trigger for investment	Timing to complete port upgrades
First movers	Construction staging	Visibility for first 500 MW (can be met by multiple projects)	Port ready for 2023
First followers	Blade manufacturing Tower manufacturing	500 MW/year beyond manufacturer’s current capability	Port ready for 2023
Second followers	Nacelle assembly Generator manufacturing	1000 MW/year for five or more years in the US market	Port ready for 2025-2026
Additional activities	Foundation manufacturing Submarine cable manufacturing	Foundations: 500 MW/year beyond manufacturer’s capability Cables: varies widely by manufacturer	Varies. Earliest port ready by 2021.

4.1. Super-port

Few ports in the world offer the required characteristics to be an offshore wind super-port. Those characteristics are:

- Proximity to a thriving offshore wind market
- More than 200 acres of under-utilized space
- Deep-water access
- No overhead navigational restrictions, and
- Existing waterside infrastructure.

The main logistical benefits of co-locating manufacturing and construction staging activities comes from avoiding the need to double-handle components and the shared use of infrastructure.

Scenario 1: Portsmouth Marine Terminal

Portsmouth Marine Terminal (PMT) offers a unique opportunity to create an offshore wind super-port by co-locating all of the primary manufacturing and construction staging activities on one site. None of the other ports has sufficient space to be a super-port.

Figure 4.1 shows an indicative layout of activities within PMT.

We estimate the total upgrade cost for the super-port scenario to range from $11 million to $25 million. This scenario carries the lowest port infrastructure upgrade cost of all scenarios analyzed. The upgrades can be phased over time, in response to market demand. The likely first phase would be upgrades for construction staging, which is estimated to cost between $7 million and $17 million.

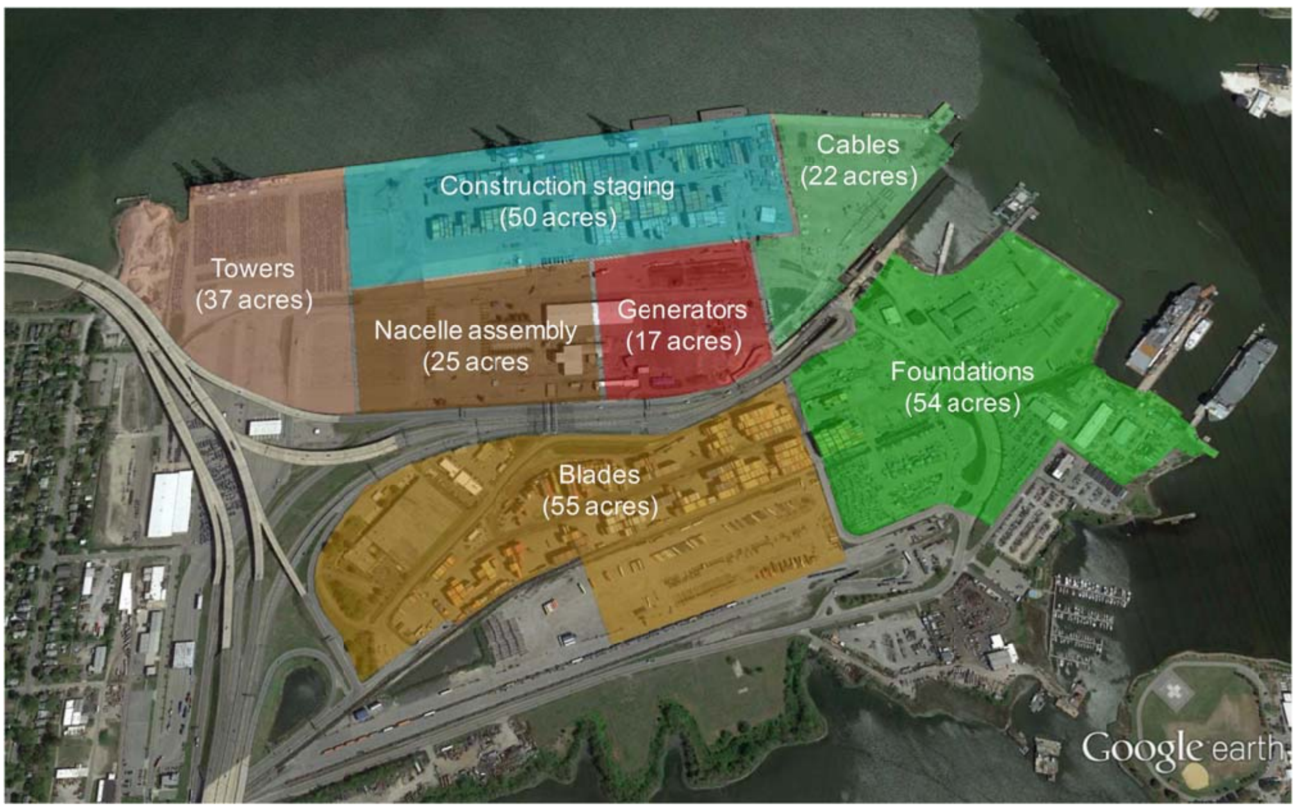

Figure 4.1 Example facility layout for super-port at Portsmouth Marine Terminal.

4.2. Cluster ports

Portsmouth Marine Terminal (PMT), Newport New Marine Terminal (NNMT) and Peck Marine Terminal (Peck) are all good candidates for cluster ports, as they have the space and vessel access to accommodate several offshore wind manufacturing and construction activities.

We developed these clustering scenarios based on co-locating activities with common vessel and waterside infrastructure needs.

We presented three cluster port scenarios in Report 2. There are additional possibilities but we would expect the implementation cost and time lines to be similar to those scenarios.

The implementation cost for these three scenarios is estimated to be between $11 million and $38 million.

Scenario 2: Portsmouth Marine Terminal and Newport News Marine Terminal

In this scenario, PMT and NNMT are used as cluster ports. The first movers are located at PMT and the followers at NNMT. The opposite is also possible and would have similar implementation costs.

Figure 4.2 shows an example layout of facilities that would maximize the use of NNMT as a cluster port.

Scenario 3: Portsmouth Marine Terminal and Peck Marine Terminal

Peck is well suited for generator manufacturing and nacelle assembly. Co-locating these two activities will reduce logistic costs. In this scenario, PMT hosts the remaining activities.

Scenario 4: Newport News and Peck Marine Terminals

This scenario is similar to Scenario 3 but replaces PMT with NNMT.

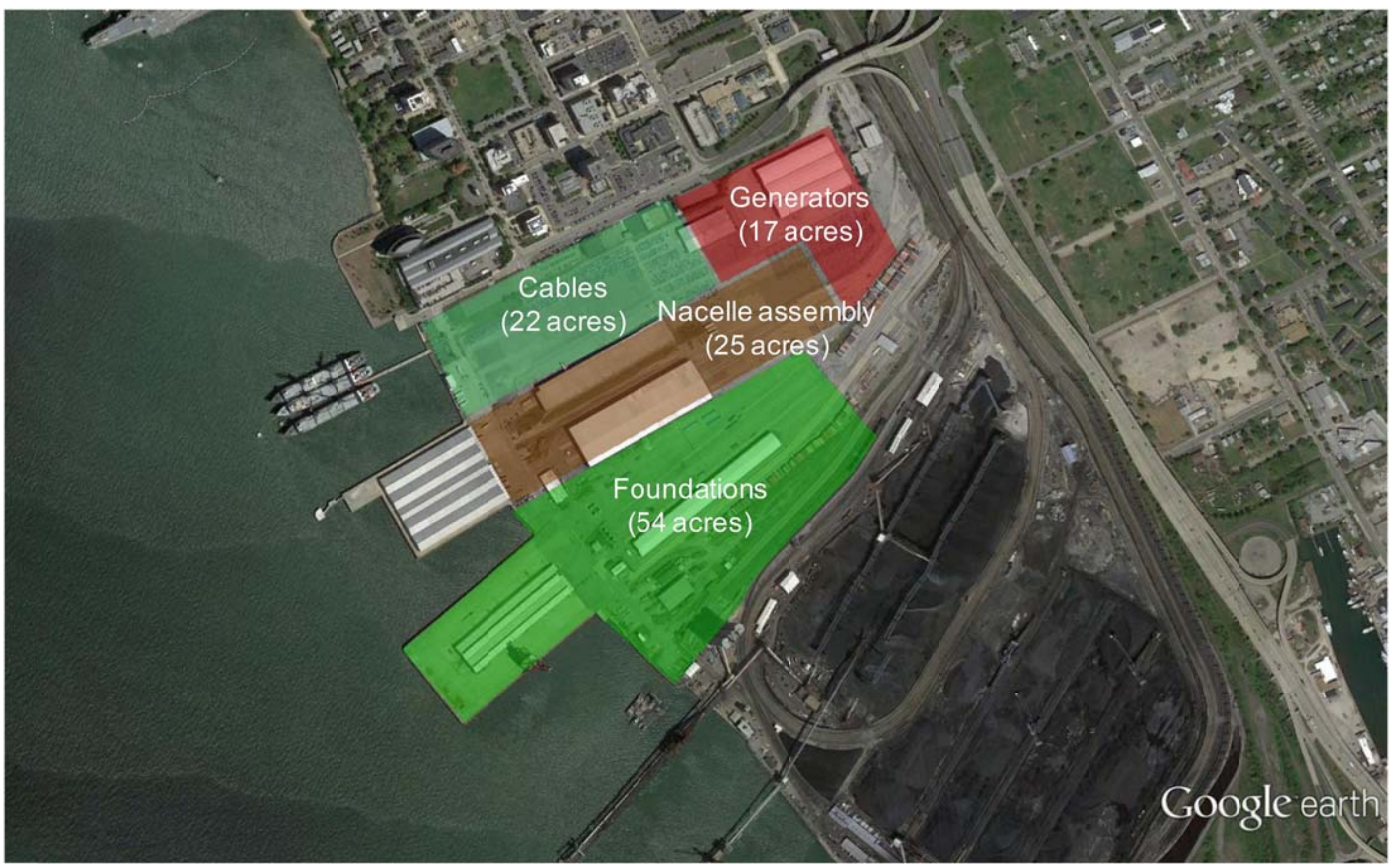

Figure 4.2 Example facility layout for cluster port at Newport News Marine Terminal (Scenario 2).

4.3. Distributed port network

A distributed port network is a natural starting point for an emerging or uncertain regional offshore wind market, as it is the most commercially agile approach to port investment (although it loses economies of scale). With this approach, each manufacturer, port owner or wind farm developer can make investment decisions in isolation and minimize their total at-risk investment.

We have presented one distributed port network scenario but many other scenarios are possible and we would expect them to have similar implementation costs and time lines. The physical characteristics of Virginia Renaissance Center mean that the site is more suited to blade manufacturing than the other activities. Likewise, Peck Marine Terminal is only well suited to tower manufacturing.

Scenario 5: PMT, NNMT, Peck Marine Terminal and Virginia Renaissance Center

This scenario uses PMT to host construction staging. The first followers are distributed between Peck (tower manufacturing) and Virginia Renaissance Center (blade manufacturing).

4.4. Port utilization summary

The five scenarios presented in this report are indicative of the many ways in which Virginia's infrastructure can support offshore wind activity. The implementation cost of each scenario is summarized in Table 4.2.

Table 4.2 Summary of port utilization scenarios and implementation costs.

Story	Scenario	Ports	Implementation cost	Construction jobs (FTE-years)
Super-port	1	Portsmouth Marine Terminal	$11 million to $25 million	29.5
Cluster ports	2	Portsmouth Marine Terminal Newport News Marine Terminal	$15 million to $36 million	46.0
	3	Portsmouth Marine Terminal Peck Marine Terminal	$14 million to $38 million	42.8
	4	Newport News Marine Terminal Peck Marine Terminal	$11 million to $33 million	37.1
Distributed port network	5	Portsmouth Marine Terminal Newport News Marine Terminal Peck Marine Terminal Virginia Renaissance Center	$20 million to $50 million	64.0

5. Potential job creation

Report 2 presents the employment activity generated by each offshore wind manufacturing activity, based on the production of 100 wind turbines per year. This includes:

- The number and classification of manufacturing and support staff jobs (measured in full time equivalent employees, or FTEs)
- The required education levels
- The required skill and certificates, in addition to education level

In addition to the direct jobs reported in Report 2, the offshore wind activities create many more indirect jobs and can attract second- and third-tier suppliers to the region.

Blade manufacturing

To manufacture 300 blades in one year (to support the installation of 100 turbines), we estimate that a total staff of 300 FTEs is needed. Since the majority of the workers in a blade plant are assemblers, the primary education level is a high school diploma.

Most of the manufacturing staff require a composite certification, such as the Certified Composites Technician (CCT) offered through the American Composites Manufacturers Association (ACMA). Blade manufacturing uses large, expensive molds that require specific maintenance. These trade workers require a CNC (computer numerical control) machining certificate.

Generator manufacturing

To manufacture 100 generator sets in one year, we estimate a total staff of 188 FTEs is needed.

A majority of the workers require post-secondary certification. This is primarily due to the skills required for the trade workers for the stator and rotor production. A minimum high school diploma is required for the assemblers, primarily working in stator and rotor assembly.

Of the manufacturing staff, 72 trade workers associated with the stator and rotor production require a post-secondary certificate. Operations with lathe or machining require CNC Machining Certificate. Operations with material cutting, welding prep, joint welding, non-destructive testing (NDT) inspection, or heat treatment and annealing require the AWS (American Welding Society) welding certificate, commonly for both line workers and supervisors. All inspector positions require quality control certification.

Nacelle assembly

To manufacture 100 nacelle assemblies in one year, we estimate that a total staff of 240 FTEs is needed. Most of the staff are assemblers, requiring only a high school diploma. Post-secondary QC inspector certification is required for the quality inspectors. Quality mangers are expected to have both QC inspector and Six Sigma Black Belt certifications.

Tower manufacturing

To manufacture 100 towers in one year, we estimate that a total staff of 105 FTEs is needed. Most of the staff are skilled trade workers, requiring post-secondary trade certification. A minimum high school diploma is required for the assemblers installing internal tower equipment, such as ladders and electronics, and painting and coating operations.

For tower production, AWS Certification is required for a majority of the skilled trade workers. The AWS certification requires specific skills plus a combination of qualifying education and work experience. QC inspector certification is required for all quality inspectors and the quality manager.

Foundation manufacturing

To manufacture 100 jacket foundations and transition pieces in one year, we estimate that a total staff of 564 FTEs is needed.

The majority of production is in welding operations by skilled trade workers requiring post-secondary or trade certification. A minimum high school diploma is required for the carboline coating, galvanize spray, paint operations, and ancillary assembly operations.

For the main lattice and the transition piece production, production, AWS certification is required for a majority of the skilled trade workers including welders, supervisors, and inspectors. QC inspector certification is required for all quality inspectors and the quality manager.

Submarine cable manufacturing

Approximately 150km of medium voltage AC array cable and 50km high voltage AC export cable is needed to support the installation of 100 turbines. We estimate that a total staff of 234 FTEs is needed, with the greatest number of staff being assembly workers.

A majority of the workers require only a high school diploma. This is because the cable manufacturing process is highly automated and requires low skilled assemblers and only a few trade workers. Higher education degrees are required for quality inspectors, and engineering and management staff.

Submarine cable is produced in a continuous line with lengths exceeding 100km. CNC machining certification is required for the electrical and mechanical maintenance crew, who are critical to ensuring continuous production. QC inspector certification is required for all quality inspectors and quality managers. Six Sigma Black Belt is preferred for support staff engineers.

Construction staging

To support the construction of 100 turbines per year on a sustained basis, our analysis shows that the facility would employ approximately 220 workers, divided into two main groups:

- Approximately 150 blue-collar and white-collar staff for the assembly of wind turbine components. This involves preparing components for installation and moving them around the construction site. They work a variety of shift patterns depending on their role.
- Approximately 70 blue-collar marine installation and commissioning staff that will support and coordinated the loading of vessels.

Summary of direct job creation

The levels of direct employment are summarized by manufacturing activity and job classification in Figure 5.1. This activity would also stimulate indirect jobs and attract second- and third-tier supplier to the region.

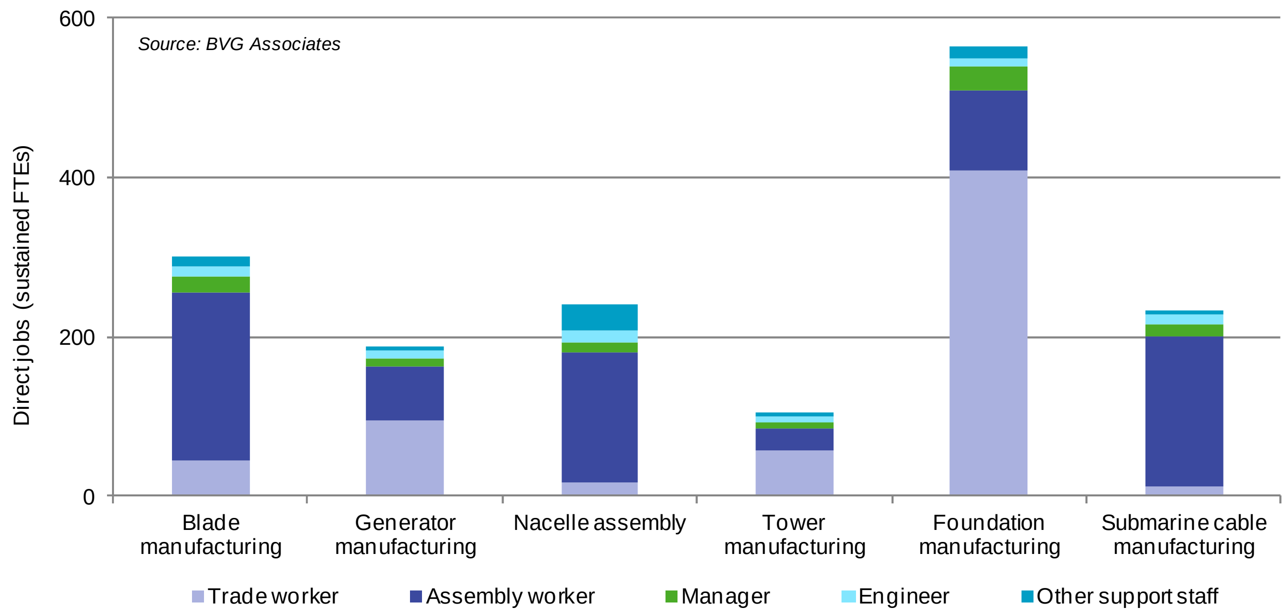

Figure 5.1Summary of offshore wind manufacturing jobs by classification.

6. Impact on cost of energy of local manufacturing

Manufacturing offshore wind components in Virginia can create significant cost savings for US east coast offshore wind farms (compared to importing components from overseas) from:

- Avoided cost of transporting components
- Avoided cost of handling components in the ports
- Avoided borrowing costs due to longer construction period, and
- Avoided cost of additional lay-down area to mitigate project risk.

Recent studies also indicate a potential costs savings from domestic component manufacturing.

Avoided cost of transporting components

Without a domestic supply chain for large offshore wind components, all wind farm components will need to be imported from Europe. We have therefore undertaken a high-level analysis of the additional logistics cost of importing components from Europe, compared with a Virginia-based supply chain. The sailing distance from northern Europe to Virginia is about 6,200km (3,800 miles). We have assumed that there is a suitable construction staging port in the Virginia and that three different vessels are used:

- A general cargo vessel (such as the BBC Amber) for transporting blades, towers, nacelles and foundations;
- A heavy-lift vessel (such as the Dockwise Mighty Servant) for transporting substations (see Figure 6.1); and
- A cable vessel (such as the Van Oord Nexus)

We have made a number of assumptions about the carrying capacity of these vessels, their charter day rate and their transit speed (see Table 6.1). From these we have calculated the cost of transporting the components (see Table 6.2) from Europe to Virginia.

Table 6.1 Assumed vessel properties for component shipping.

Vessel type	Cargo	Transit speed	Day rate
General cargo	Blades, nacelles, towers	15 knots	$20,000
Heavy-lift	Foundations, sub-stations	15 knots	$40,000
Cable	Submarine cable	15 knots	$40,000

Table 6.2 Shipment costs for wind farm components.

Component	Number in 500MW wind farm with 6MW turbines	Number on each vessel	Total shipping cost per 500MW wind farm
Blades (sets)	83	6	$4.7 million
Towers	83	5	$5.7 million
Nacelles	83	24	$1.2 million
Foundations (jackets)	83	5	$11.5 million
Sub-stations	2	1	$1.4 million
Submarine cable (array cable)	125km	125km	$0.7 million
Submarine cable (export cable)	100km	100km	$0.7 million
Total shipping costs from Europe to Virginia for 500 MW wind farm			**$25.9 million**

Figure 6.1 Transport of Dolwind 2 offshore substation on the Dockwise Mighty Servant.

Avoided cost of handling components

The amount of additional handling will depend on the port utilization approach discussed in Section 1. The avoided costs are maximized in the super-port and cluster port scenarios. In a distributed utilization port network, there would be little to no avoided component handling costs.

Avoided borrowing costs

Supplying a wind farm with overseas components introduces a risk for just-in-time equipment delivery. This risk would probably be mitigated by extending the planned construction season by one year, to allow for an additional summer construction season. As a result, up to 25% of the wind farm capital expenditure (CAPEX) could be subject to an additional year's borrowing costs at an annual percentage rate of approximately 10%. The CAPEX of a wind farm constructed in the early 2020s will cost approximately $2.5 billion in current values, making the total additional borrowing approximately $60 million.

Avoided cost of additional lay-down area

The amount of additional lay-down area would depend on the construction schedule adopted by the wind farm developer. The overall cost of additional lay-down area depends on several factors such as amount of space required, duration of lease, and lease rates. At this time there are too many unknowns to estimate this cost, but we expect it to be less than the other costs mentioned above.

Domestic component manufacturing

In a report published in April 2010, the Virginia Coastal Energy Research Consortium (VCERC) described the development and validation of an offshore wind cost model for a hypothetical 600 MW project off the coast of Virginia.[1] The study estimated a 13% to 14% reduction in the cost of energy from domestic manufacturing of the turbine and tower package.

A more recent study by the Global Wind Network[2], funded by the U.S. Department of Energy and published in June 2014, compares offshore wind manufacturing costs in the U.S., Germany, and China for a notional 5MW turbine on a lattice-jacket foundation substructure (Reference 2). It estimates that the U.S. has significantly lower manufacturing costs than Germany for towers, blades, and jacket foundation substructures. It said that only permanent-magnet generators are more costly when manufactured in the U.S.

These two studies illustrate the potential for cost savings from US manufacturing. Such savings are likely to be dependent on the investment appetite of US suppliers and the strength of demand from US offshore wind projects.

Total impact on cost of energy

The total avoided cost for a 500MW wind farm is estimated to be approximately $86 million. This means the avoided cost due to local manufacturing is approximately 3% of the total project CAPEX.

Taking account of all potential costs, the overall logistical benefit of local manufacturing is approximately 2% of the cost of energy, excluding any change in ex-factory component costs.

Given the overall scale of the project, such a saving is still a significant amount of money but there are also other factors that developers and suppliers will also consider when planning to new facilities in the US.

For example, this logistic cost benefit could easily be reduced, or lost entirely, through:

- Higher costs of capital due to an increased levels of perceived risk associated with new facilities and supply chains
- Transportation cost of sub-assemblies and sub-components from existing supply chains in Europe, and

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[1] Virginia Coastal Energy Research Consortium, 2010. Virginia Offshore Wind Studies, July 2007 to March 2010, Final Report

[2] Global Wind Network, 2014. U.S. Wind Energy Manufacturing and Supply Chain: A Competitiveness Analysis.

- The additional costs of supporting the growth of new sub-suppliers in the region.

Overall, therefore, it is likely that consideration of logistic costs and potential domestic manufacturing costs will be important but not decisive factors in motivating companies to set up new facilities on the US east coast for early projects, but in time, the proposition will be de-risked and become more attractive. In addition to logistics and component manufacturing costs, we expect their decisions to be driven by other considerations, such as:

- The need for additional capacity due to strong growth in the market, and
- Political pressure for increasing levels of local benefit of offshore wind.

7. Regional port assessment

We undertook an evaluation of US east coast ports that could potentially compete with Virginia to serve the regional offshore wind market. This section presents a summary of the evaluation, including the methodology, findings, and conclusions. The full report is included as Appendix 1 of this report.

7.1. Methodology

Geographic scope

We considered Bureau of Ocean Energy Management (BOEM) wind energy areas and call areas within 250 nautical miles (nm) of Cape Henry, Virginia, which is situated at the mouth of Chesapeake Bay. These areas comprise the serviceable market for Virginia ports to provide construction staging services, as the areas are approximately within one day's transit from Virginia ports. The areas are (from north to south):

- New York call area
- New Jersey call area
- Delaware proposed lease area
- Maryland lease area
- Virginia lease area
- North Carolina (Kitty Hawk) call area

Likewise, the geographic scope of the regional port assessment includes ports within 250nm of any of the above areas. The northernmost port included in the geographic scope is New Bedford, MA[3]. The southernmost post is Morehead City, NC[4].

The serviceable market for Virginia-manufactured offshore wind components is larger than construction staging services. Finished goods can be supplied directly to the above areas and shipped to staging ports further north or south and deployed to the following additional areas:

- Massachusetts wind energy area
- Massachusetts lease area
- Rhode Island /Massachusetts lease area

Evaluation criteria

We screened ports within the geographic scope for their potential to serve as an offshore wind super-port or cluster port. We used the same port requirements that were used in the Virginia port evaluations (see Report 1).

7.2. Port Evaluations

Our analysis included evaluations of ports in line with the methodology described in Report 1, but did not include any implementation analysis for required port upgrades.

Initial findings

No potential super-ports were identified.

Seventeen ports were identified as potential competitors to Virginia ports. They can be grouped as follows:

- 11 potential cluster ports, accommodating two to three offshore wind activities
- 1 port accommodating one to two activities
- 5 ports accommodating only one activity

The five ports that can only accommodate one offshore wind activity are not deemed strong competitors to the group of Virginia ports that together can host all activities. Furthermore, seven of the potential clusters ports are already highly utilized and we consider it unlikely that they will actively compete with Virginia ports to attract offshore wind activities. The remaining four potential cluster ports can be considered likely competitors to Virginia ports. These four ports are:

- Paulsboro, NJ (likely to be most competitive)
- Sparrows Point (Baltimore), MD
- New Bedford, MA
- Quonset Point, RI (least competitive)

Evaluation: Paulsboro, NJ

Paulsboro, NJ is currently being built to offshore wind specifications and will offer approximately 150 acres of space and a 450m quay with 12m draft.

There is enough space to accommodate two to three offshore wind activities, making it a potential cluster port. A steel slab manufacturer holds a lease for 50 acres. Bridges restrict navigational overhead clearance to 57m.

The port's primary strengths are ample space to create a cluster port and infrastructure built to offshore wind specifications. The port's primary disadvantages are the distance to sea (about 65 nm) and overhead restrictions.

[3] Technically, New Bedford is outside the geographic scope. However significant port upgrades have recently been completed with the specific intent of establishing New Bedford as an offshore energy hub.

[4] Wilmington, NC is outside the geographic scope of this study.

Paulsboro would compete with Virginia ports to service most, if not all, of the wind energy areas within Virginia's geographic scope.

Evaluation: Sparrows Point (Baltimore), MD

Sparrows Point has enough space to accommodate several offshore wind activities. The infrastructure is aging and in need of repair. There are currently no known plans to upgrade quay and ground strength, which would be needed to attract offshore wind activities.

The size, proximity to Virginia, and potential for public investment make Sparrows Point a likely competitor to Virginia ports.

Evaluation: New Bedford, MA

The New Bedford Marine Commerce Terminal is a relatively small site (28 acres) that has recently been upgraded to meet offshore wind specifications. It will be used by the 130-turbine Cape Wind for construction staging, if the project moves forward.

The site's primary strength is that no further upgrades are required to accommodate offshore wind. The site's primary drawback is lack of space, which precludes the potential synergies of a cluster port.

New Bedford would likely only compete with Virginia ports for construction staging activity for the northern-most wind energy areas, such as Massachusetts, Rhode Island, New York and New Jersey.

Evaluation: Quonset Point, RI

Quonset Point has a similar profile to New Bedford, MA. Quonset Point has a total of 60 acres, with 36 acres currently available. The port has recently been upgraded to meet offshore wind specifications. It is being used to stage Deepwater Wind's five-turbine demonstration project off the coast of Block Island.

The site's primary strength is that no further upgrades are required to accommodate offshore wind. The site's primary drawback is lack of space, which precludes the potential synergies of a cluster port.

Again, Quonset Point would likely only compete with Virginia ports for construction staging activity for the northern most wind energy areas, such as Massachusetts, Rhode Island, New York and New Jersey.

7.3. Summary of findings

We evaluated ports along the US east coast to identify potential competitors to Virginia's ports for attracting offshore wind manufacturing and construction staging activities.

No potential super-ports were identified.

Two potential cluster ports were identified: Paulsboro, NJ and Sparrows Point (Baltimore), MD. Paulsboro is likely to be the strongest competitor to Virginia ports, as it being constructed to offshore wind specifications.

Two competitors were identified that are likely to compete with Virginia ports for construction staging activity: New Bedford, MA and Quonset Point, RI. Both ports are built to offshore wind specifications but are relatively small and have limited serviceable area in common with Virginia's ports.

8. Investment opportunities

We have identified four investment opportunities and prepared a high-level summary for each. Our recommendations are in Section 9.

8.1. Portsmouth Marine Terminal: quayside and ground strength upgrades

Investment summary

Upgrading the quayside strength and ground strength at PMT. This would enable the creation of a world-class offshore wind super-port.

The current quayside infrastructure requires new support piles, new decking, and other ancillary upgrades. The upland areas require ground strengthening with cross-laminated timbers laid in component storage areas and crane paths.

The upgrades can be completed in phases, in response to market demand.

Required completion date

When establishing required completion dates we are assuming an installation rate of 500MW per year starting in 2023 (ie. first project complete in 2025) and ramping up to 1500MW per year in the 2030's. Alongside this, we assume the first supply from local manufacturing facilities will be in 2025, after the early projects are installed.

The first phase of port upgrades would probably need to be ready by the end of 2022, to support construction staging of the first 500MW offshore wind farms in (say) 2023. Depending on market developments, this time line could be accelerated or delayed. If there were opportunities to establish early manufacturing facilities, say for foundations that are required in series quantities in 2023/4, then some upgrades would be needed earlier, in order to give time for facilities to be constructed.

Market triggers

A financial investment decision (FID) to build at least 500MW of offshore wind in the Virginia, Maryland, Delaware, Kitty Hawk or New Jersey offshore wind energy areas (WEAs) would generate firm demand for a local construction port.

Increasing market certainty in an ongoing regional pipeline of activity would generate demand for local ports to host manufacturing activities.

Outcomes

At full capacity, a super-port could support more than 1,500 direct jobs (sustained FTEs) and stimulate strong growth in second- and third-tier suppliers, providing a total of many more indirect and induced jobs.

The port upgrades would generate approximately 30 construction jobs (FTE-years).

Project scope

The overall project comprises the following steps, which can be executed as stand-alone sequential sub-projects:

- Design and permitting
- Demolition and environmental containment
- New support piers, decking, pavement, bollards, and fendering
- Placement of cross-laminated timbers

Implementation cost

Preparing the port for construction staging is expected to cost \$7 million to \$17 million. With additional investment of \$4 million to \$7 million, the port could be prepared to accommodate all seven offshore wind activities.

These costs do not include the investment by manufacturers to build factories and otherwise develop the site for their specific needs.

Implementation timeline

Preparing the port for construction staging will take two-and-a-half years, inclusive of a one-year engineering and permitting process. The timeline for preparing the ports for the manufacturing activities ranges from 23 to 30 months, inclusive of permittingand could be completed concurrently within the timeline of the construction port upgrades.

The timeline for developing port "superstructure" (buildings, machinery, cranage) varies by manufacturing activity and must also be considered in the overall timeline. Some of this activity, again, can be concurrent with port work.

Risks

The primary risk for Virginia is investing too heavily in advance of a highly uncertain market. If the market does not materialize, it will be difficult to recover the investment from other port users that do not require the full port capabilities.

This risk can be mitigated by taking a phased approach to investing. The up-front design and permitting requires one year to complete and the costs are a small fraction of the total investment. If completed, this up-front work removes a potential barrier to an inward investor, thereby enabling them to plan with more confidence for activity in Virginia. It also brings timescales for port upgrades and facility development more closely in line with project construction timescales, from the point of FID.

The risk can also be mitigated by attracting complementary offshore oil and gas activities, which have a similar port specification to offshore wind.

8.2. Newport News Marine Terminal: quayside and ground strength upgrades

Investment summary

Upgrading the quayside strength and ground strength at NNMT. This would allow the creation of an offshore wind cluster port hosting wind farm construction staging and multiple manufacturing activities.

The profile of this investment opportunity is similar to the PMT opportunity. Similar quay and ground strength upgrades are needed and the work can be completed in phases.

Required completion date

The first phase of upgrades would probably need to be ready by the end of 2023, to support construction staging of the first 500MW offshore wind farms. Depending on market developments, this time line could be accelerated or delayed.

Market triggers

The market triggers are the same as for PMT.

Outcomes

At full capacity, a cluster port could support more than 1,100 direct jobs (sustained FTEs) and stimulate strong growth in second- and third-tier suppliers.

The port upgrades would generate approximately 45 construction jobs (FTE-years).

Project scope

The overall project comprises the following steps, which can be executed as stand-alone sequential sub-projects:

- Design and permitting
- Demolition and environmental containment
- New support piers, decking, pavement, bollards, and fendering
- Placement of cross-laminated timbers

Implementation cost

Preparing the port for construction staging is expected to cost $7 million to $14 million. With additional investment of $4 million to $8 million the port could be prepared to accommodate up to four offshore wind activities.

These costs do not include the investment by manufacturers to build factories and otherwise develop the site for their specific needs.

Implementation timeline

The time line for upgrading NNMT is similar to PMT.

Risks

The risks and mitigation strategies are the same as for PMT. Investing ahead of the market demand carries the risk of developing an over-specified port. At the same time, it helps to secure the manufacturing opportunity for Virginia by raising a barrier to entry for other regions.

8.3. Peck Marine Terminal: quay extension, ground strengthening, and dredging

Investment summary

Extending the quay, dredging alongside the quay, and strengthening the ground at Peck. This could enable the creation of an offshore wind cluster port hosting multiple manufacturing activities.

The current quay is in good condition but needs to be extended. The upland areas require ground strengthening with cross-laminated timbers laid in component storage areas and crane paths.

The upgrades can be completed in phases, in response to market demand.

Required completion date

The first phase of upgrades would probably need to be ready by the end of 2022, to allow manufacturers a two-year window to build factories and be ready to start series manufacturing in 2025. Depending on market developments and the demand for early local manufacturing of components, this time line could be accelerated or delayed.

Market triggers

A strong demand for 500MW to 1,000MW per year would generate firm demand for local manufacturing, with investment decisions to establish manufacturing of towers and blades requiring a smaller market demand than nacelle assembly.

Outcomes

At full capacity, a cluster port could support more than 400 direct jobs (sustained FTEs) and stimulate strong growth in second- and third-tier suppliers.

The port upgrades would generate approximately 10 construction jobs (FTE-years).

Project scope

The overall project comprises the following steps, which can be executed as stand-alone sequential sub-projects:

- Design and permitting
- Dredging
- Quay extension
- Storm water pond back-fill and remediation
- Placement of cross-laminated timbers

Implementation cost

Preparing the port for offshore wind manufacturing activities is expected to cost from $2 million to $14 million.

These costs do not include the investment by manufacturers to build factories and otherwise develop the site for their specific needs.

Implementation timeline

Preparing the port for manufacturing will require 2.5 years, inclusive of permitting.

Risks

The risks and mitigations are the same as at PMT and NNMT. Additionally, at Peck there is the risk of investing in an over-specified port. For example, blade manufacturing requires a lower specification than nacelle assembly.

As with the other ports, the risks can be mitigated by investing in design, permitting, and engineering while stopping short of investing in construction and dredging without the appropriate market signals.

8.4. Virginia Renaissance Center: ground strengthening and dredging

Investment summary

Dredging alongside the quay and strengthening the ground at VRC. This could enable a blade manufacturer to build a factory at VRC.

The current quay is in good condition but maintenance dredging is needed. The upland areas require ground strengthening with cross-laminated timbers laid in component storage areas and crane paths.

Required completion date

The first phase of upgrades would probably need to be ready by the end of 2023, to allow a blade manufacturer a two-year window to build a factory and be ready to start manufacturing in 2025.

Market triggers

A strong demand for 500MW to 1,000MW per year would generate firm demand for local manufacturing, with towers and blades requiring a smaller market demand than nacelle assembly.

Outcomes

At full capacity, a cluster port could support more than 300 direct jobs (sustained FTEs) and stimulate strong growth in materials suppliers.

Project scope

The overall project comprises the following steps, which can be executed as stand-alone sequential sub-projects:

- Design and permitting
- Dredging
- Purchasing and placement of cross-laminated timbers

Implementation cost

Preparing the port for blade manufacturing is expected to cost from $1 million to $5 million.

These costs do not include the investment by manufacturers to build factories and otherwise develop the site for their specific needs.

Implementation timeline

Preparing the port for manufacturing will take less than six months inclusive of permitting. Establishing serial manufacturing facilities will take up to 2 years, depending on the facility.

Risks

Investing in VRC is a relatively low-risk opportunity. Completing the dredging project could stimulate interest from other users until such time as a blade manufacturer is ready to invest in VRC. Ground strengthening should only be completed if needed.

9. Recommendations

We have developed a set of market-driven, time-based recommendations for the three key offshore wind industry enablers in Virginia:

- DMME – The Virginia Department of Mines, Minerals, and Energy
- VEDP – The Virginia Economic Development Partnership, and
- VPA – The Virginia Port Authority.

We intend these recommendations to form the basis of a roadmap toward the creation of a sustainable offshore wind hub in Virginia. They are meant to be pragmatic and realistic, and not overly cautious nor aggressive.

We split the recommendations over four periods. In each one, we have described some key market signals that should indicate progress is being made in the US east coast offshore wind market. Our recommended actions for Virginia enablers are tied to these market signals, and eventually, firm commitments relating to specific projects. In the absence of positive signals from the offshore wind industry, we recommend a "wait-and-see" approach to the more costly actions.

The recommendations are based on an installation scenario of 500MW per year starting in 2023 (ie. first project complete in 2025) and ramping up to 1500MW per year in the 2030's. Alongside this, we assume the first supply from local manufacturing facilities will be in 2025, after early projects are installed. There is a chance that installation (or local supply) could happen earlier, driven by federal and state policy changes and supplier appetite for risk, in which case some recommended actions would need to be accelerated compared to what is presented below.

2015 to 2017

Market signals

Offshore wind developers will either have secured, or be competing for, leasing rights to the outer continental shelf (OCS) wind energy areas and will be starting early planning and consenting activities. This means they will be focused on establishing project economic and technical feasibility. An important market signal will be whether a small number of projects are able to submit permit applications by the end of 2017.

Recommended action: Make the socioeconomic case for offshore wind manufacturing and construction staging in Virginia

DMME should build upon the findings of this study (direct job creation) and investigate the full socioeconomic benefits of a Virginia-supported offshore wind industry, including wider supply chain growth, building on the logistical benefits of local supply, the regional strengths that it has and the anticipated greatest supply chain gaps that there will be. DMME should then share these findings with Virginia decision makers to highlight the industrial benefits of an offshore wind programme in Virginia. In addition to creating the 1500direct manufacturing jobs identified in this study, many other indirect jobs would be created and second- and third-tier suppliers would be attracted to the region.

Recommended action: Establish a preferred port scenario

DMME should lead an effort with VPA and VEDP to align objectives and prepare a joint master plan for the role of Virginia ports in an offshore wind industry. This master plan should take account of existing port users, rival users for upgraded facilities and the full socioeconomic benefit of investment. Engagement with private port owners should be part of this process, to ensure alignment.

This report should be published to send a clear signal to the offshore wind industry that the Commonwealth is Virginia is coordinated and ready to support the offshore wind industry. Publishing the report could draw out interested parties and enable early dialog with potential inward investors.

Recommended action: Monitor other regional port developments

Paulsboro, NJ and Sparrows Point (Baltimore), MD could move forward with port infrastructure improvements targeted at attracting an offshore wind supply chain during this period. Virginia enablers should monitor the progress of regional ports and consider adjusting the preferred port scenario accordingly.

Recommended action: Coordinate a Virginia port marketing prospectus

With the potential for project developers and manufacturers to be working toward large-scale investment decisions, Virginia enabler bodies should ensure they are united with a clear and consistent message. This includes establishing a single point of contact for commercial and technical questions, creating a library of useful documents and ensuring that politicians and local stakeholders are educated about the offshore wind opportunity. Developing a ports prospectus during this early time period will help establish

Virginia as the go-to location for offshore wind manufacturing and construction staging for the east coast.

2018 to 2020

Market signals

Developers should be completing the consenting process on early projects and progressing toward a financial investment decision (FID) by 2021.

We would also expect BOEM to have granted additional OCS lease awards, followed by new consenting applications, as the market builds momentum behind the early developers.

Greater clarity of longer-term activity into the 2020s may stimulate early interest from offshore wind suppliers to start identifying potential manufacturing locations.

Recommended action: Determine the required timing for port upgrade completion

DMME should engage with the developers and the supply chain to gain an up-to-date understanding of when specific port upgrades to be completed. In particular, DMME should seek to understand whether infrastructure investment is needed ahead of wind farm FIDs to secure opportunities for domestic supply of components. This timeline should also take account of superstructure development (including buildings, machinery and cranage) and the need to ramp-up production volumes over time, in order to ensure high quality supply of components. There is a risk that if infrastructure investment decisions are required before wind farm project FID, in order to keep to project timescales. If this is the case, then Virginia may need to act somewhat speculatively. Learning from European processes that have addressed this dilemma on various ports is worth obtaining, as it may help unlock timely investment.

Recommended action: Remove potential barriers to port upgrades

If the market is sending positive signals, then DMME and VPA should undertake preliminary design, permitting, and engineering work for agreed port upgrades.

Completing this work will not need a large investment and will make it easier for inward investors to confidently plan their projects. This action sends a clear signal that Virginia is prepared to proactively support the development of a supply chain and brings port upgrade timelines more closely in line with project timelines.

Recommended action: Further enhance marketing proposition

At this point, further information on rental costs, timescales and benefits of Virginia ports will be required, as investors start to carry out more detailed due diligence.

2021 to 2023

Market signals

Offshore wind developers should be reaching FID on a pipeline of projects so that a number of projects are installed and commissioned by the end of this period. We would also expect BOEM to continue leasing OCS sites to new projects. Second and third round projects should be progressing through the consenting process.

Recommended action: Secure inward investment from manufacturers and complete the port upgrades

If the market is sending positive signals and projects are reaching FID, then this is the time to secure commitments and complete the port upgrades to enable construction staging of the earliest projects.

With port upgrades underway, the manufacturers can commit to and start building facilities at the ports, such that early manufacturing can commence by the end of this period.

2024 and beyond

The offshore wind industry should be well on its way by this period. If so, DMME, VEDP, and VPA should still be playing a key supporting role the development of local supply chains to serve new manufacturing facilities and in highlighting the benefits of activities in Virginia, both for the industry and the state.

If the US offshore wind industry is developing more slowly than has been presented above, some of the recommendations from the previous time periods will be applicable during this period.

Appendix 1: Regional ports assessment

May 22nd, 2015

Regional Competitive Ports Assessment

As part of the Virginia Offshore Wind Port Readiness Evaluation

For the Commonwealth of Virginia’s DEPARTMENT OF MINES, MINERALS and ENERGY (DMME)

On behalf of BVG ASSOCIATES

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Acronyms and Abbreviations

APM	Container terminal operating company
DMME	Division of Mineral, Mines and Energy
ha	hectare
m	meter
m^2	square meter
MA	Massachusetts
MD	Maryland
MLLW	Mean Lower Low Water
NC	North Carolina
Nm	nautical miles
NJ	New Jersey
NY	New York
PA	Pennsylvania
PANYNJ	Port Authority of New York and New Jersey
PNCT	Port Newark Container Terminal
PSF	Pound per Square foot
RI	Rhode Island
R&D	Research and Development
SC	South Carolina
SF	Square foot
SQM	Square meter
t/sqm	ton per square meter
t/m^3	ton per cubic meter
VA	Virginia
WEA	Wind Energy Area

Executive summary

This report presents the results of a regional analysis of major industrial ports on the East Coast of the United States with respect to their capability to serve the offshore wind industry.

This study is part of the Virginia offshore wind port readiness analysis for Virginia's Department of Mineral, Mines and Energy (DMME) conducted by a team led by BVG Associates.

The goal of the regional port assessment is to identify ports on the Mid-Atlantic East Coast that have the potential for establishing offshore wind manufacturing operations and could compete with the ports of Virginia over projects.

Offshore wind projects in the Atlantic projected to become operational within the next 10 years set the stage for the study. We have reviewed the opportunities for offshore wind manufacturers to set up operations at the various port sites. Six types of offshore wind manufacturing activities were taken into account: Blade manufacturing, nacelle assembly, tower, jacket foundation, generator and submarine cable manufacturing.

Drawing from the specific requirements of the manufacturers we developed a set of criteria for evaluating the ports.

The assessment of Virginia's ports in BVG's report No. 1 has shown that Virginia has a great potential to become an offshore wind hub: Virginia's Portsmouth Marine Terminal and also Newport News Marine Terminal show a great potential to become an offshore wind manufacturing and deployment cluster. Cluster ports are ports that have the capability of serving more than 2 or 3 offshore wind manufacturing activities and could serve as a catalyst for the industry as additional labor and work associated with the industry supply chain along with repair shops, R&D etc. could be attracted and could result in additional jobs and revenue for the region.

This competitive analysis therefore focused on identifying regional ports with similar or better capabilities than Virginia's ports. Regional ports with the ability to potentially attract two or three offshore wind manufacturers might compete with the ports of Virginia over these construction jobs.

As Virginia's port terminals have very busy ongoing operations this analysis also took into account the utilization rate of the ports (as information was available). An under-utilized port in the region with strong capabilities for offshore wind manufacturing might become a strong competition to Virginia.

The findings are presented in detail per port and in an overall summary of all ports.

Findings

Based on their terminal infrastructure and navigational access criteria, eleven ports would have the potential to become manufacturing clusters for more than 2-3 offshore wind activities. One port could launch 1 to 2 offshore wind operations at their terminal site and five ports could accommodate 1 offshore wind activity based on this evaluation.

Most of these potential cluster ports are container ports or very busy cargo and ro-ro ports i.e. for car imports and processing. The business model of these ports suggests that offshore wind with its long term lease requirements is a competing element to the ongoing operations.

Therefore Seagirt, Dundalk, Masonville, AMPORT, Global's New York and New Jersey Container Terminals, APM Terminal, Maher Terminal and Port Newark Container Terminal are not deemed to be a competition for offshore wind projects although they would have the capability to accommodate a line of manufacturers.

The ports of Wilmington, Penn Terminal, Philadelphia's Packer Avenue and Tioga Terminal, Quonset Point, RI and New Bedford's Marine Commerce Terminal would have the capability for 1 or 2 offshore wind activities. However it has been shown that at least 2 to 3 manufacturing entities are needed to launch the offshore wind industry at a new location. Therefore these ports are not deemed to be a competition to the port of Virginia with respect to offshore wind projects.

Sparrows Point just outside of Baltimore, MD and the port of Paulsboro, NJ have the potential for a cluster port. Sparrows Point is currently being cleaned up and redeveloped. Due to its large site, it would be in a good position to develop an offshore wind manufacturing hub and could become a (serious) competition to Virginia. However, the development of the site is still undecided at this point.

The port of Paulsboro is currently being constructed. Its design includes heavy lift bearing capacity as offshore wind had been previously identified as a potential business line.

Quonset Point, RI and New Bedford, MA which both have undertaken infrastructure investments in the offshore wind industry would be considered a marginal competition over offshore wind projects to Virginia due to their limited terminal area sizes.

We recommend watching the developments at the ports in New York and New Jersey and in Baltimore, MD and following the developments at Paulsboro, NJ and Sparrows Point, MD very closely. The ports of Paulsboro and Sparrows Point might become a serious competition over offshore wind projects that Virginia could go after. Notably, the port of Paulsboro, NJ could be serving all offshore wind projects within Virginia's geographical scope.

Background

The shipping and port industry are currently undergoing major changes. Some of them are related to the widening of the Panama Canal (completion estimated for early 2016 according to their official website). Vessels able to travel the widened Panama Canal, Post-Panamax vessels and Suez Canal vessels pose increased requirements to the ports infrastructure and navigational access. Therefor rivers such as the Delaware Canal and the channels of the port of New York and New Jersey are being dredged deeper. The Bayonne bridge in New York is also being elevated to accommodate access to higher vessels. Ports are also heavily investing in bigger and wider cranes and larger laydown and staging areas among other infrastructure upgrades such as expanded rail-yards. These investments would also partly benefit the offshore wind industry.

Other port sites are currently planned or developed. Along the Delaware River which is being dredged down to 13.7 m (45') four new port developments are discussed. One is the planned Southport marine terminal in Philadelphia, a planned 220 acre terminal just south of the Packer Avenue Terminal. Its initial development plans include a bulk facility, container terminal and logistics yard next to the existing Greenwich Intermodal Yard; however a developer has not been chosen and plans are still flexible (conversation with Sean Mahoney, Philadelphia Regional Port Authority on April 22, 2015). Another planned port is New Castle's Riversedge Industrial Park, a 176 acres site just south of the port of Wilmington, DE. Development plans include a container terminal; however due to its position south of the Delaware Memorial Bridge this port would also have the potential to become a staging port for offshore wind. Another planned development is the former DuPont facility in Gibbstown, NJ; no details are confirmed at this stage. The fourth port development is the port of Paulsboro in Gloucester County, NJ which is currently being built. Its infrastructure was designed with offshore wind requirements in mind. The first current construction phase includes the setting of the wharf and a rail yard.

Lastly, New Bedford, MA is in the final phase of constructing its Marine Commerce Terminal, a multi-purpose terminal purposefully built for the offshore wind industry.

This analysis has reviewed developed ports and those currently under construction including New Bedford, MA and Paulsboro, NJ. Port developments in the planning stage, i.e. Southport in Philadelphia, PA, Gibbstown, NJ or Riversedge in New Castle, DE (near Wilmington, DE) have not been included in the analysis.

The regional port assessment identified and evaluated ports on the Mid-Atlantic East Coast that might be able to establish an industry for offshore wind manufacturing. Six manufacturing facilities were taken into account and a set of criteria was developed to measure the ports capability to accommodate those activities at their sites.

This assessment reviewed blade manufacturing, nacelle assembly, tower, jacket foundation, generator and submarine cable manufacturing activities. Construction staging itself has not been reviewed.

An initial port screening by Clarendon Hill Consulting had shown that developed ports within the geographic scope would not be able to become a super port. A super-port was defined as a staging port with large developed terminal space to accommodate two to three manufacturing functions.

The methodology section gives insights on how the criteria set was derived, what ports have been identified in the first screening and how these were evaluated in the second screening.

The results are then presented and compatibility for respective offshore wind activities is assessed per port.

An overall summary of the ports capabilities is given followed by a summary of findings and recommendations.

Methodology

This study has reviewed and screened ports within a defined geographical scope for their capability to be used for offshore wind manufacturing activities. The focus has been put on identifying ports with the capability to serve more than 2 or 3 offshore wind activities as these might add enough momentum for the industry to kick off.

The methodology section describes the geographical setting or scope, the screening criteria developed to assess the ports' capability to be used by offshore wind manufacturers and the actual port assessment.

We conducted the evaluation as following:

1. Set geographical scope
   a) identified Wind Energy Areas (WEA) within a travel distance of 250 nm that could be served from the port of Virginia
   b) identified regional ports within up to 250 nm travel distance by vessel from each of the identified Wind Energy Areas.

2. Set screening criteria for 1st and 2nd tier screening
   a) identified a minimum criteria set which applies to all offshore wind manufacturing activities
   b) identified a set of port requirements for each of the screened offshore wind manufacturing activities, blades, nacelles, tower, jacket foundation, generators, and cable manufacturing and load out.

All screening criteria are based on the Virginia Offshore Wind port readiness evaluation report 1.

3. Assessed ports within the geographical scope based on 1st tier screening criteria

We researched the parameters for the ports within the geographical scope based on:

- desktop research
- interviews with port owners and operators (as applicable)
- Email exchange with ports

4. Port evaluation (2nd tier screening)

We reviewed the ports that met the 1st tier screening criteria for their suitability for each of the offshore wind activities.

1. Geographical Scope

BOEM's offshore wind areas (that would become operational within the next 10 years) have been identified within a radius of 250 nm from the Hampton Roads bridge tunnel. These projects could become potential customers for Virginia's ports.

The maximum traveled distance from port to construction site derives from various factors including suitable ports and available vessels among others. High vessel leasing and operation costs including fuel costs and an increasing risk associated with transporting components over a longer distance to the construction site set the framework for the maximum traveled distance. A vessel transiting at ~ 10+ knots can travel about 250 nm within a day. This study therefor choose 250 nm traveled by vessel as the maximum distance for the location of a port from the Wind Energy Area. Locations within a greater distance are not deemed technically and economically feasible under current circumstances.

Results:
The table below shows the identified Wind Energy Areas within 250 nm travel distance from Virginia ports[1]:

Table 1 Estimated Travel Distance to Wind Energy Areas from Virginia's Hampton Roads Bridge Tunnel

Wind Energy Area	Estimated Travel Distance from Hampton Roads Tunnel Bridge*
New York WEA	250 nm
New Jersey WEA	180 nm
Delaware WEA	120 nm
Maryland WEA	100 nm
Virginia WEA	30 nm
North Carolina WEA Kitty Hawk	60 nm

* travel distance via regular shipping routes and traffic separation schemes

We then identified regional ports within 250 nm from each of those Wind Energy Areas (WEAs). These are considered potentially competing ports for offshore wind construction activities.

The radius of the study area reached from Massachusetts' New Bedford which could compete for the furthest WEA that could be staged and served from Virginia's ports, New York (250 nm travel distance from Virginia's Hampton Roads to WEA New York) to northern North Carolina (Morehead City) which could compete for North Carolina's Kitty Hawk WEA.

Distance was measured using nautical charts and applying general travel routes such as shipping and travel separation lanes. Table 4 shows the results of the measured distance from each of the ports to the WEA within 250 nm.

The following chapter describes which regional ports fall within the geographical scope of this study and have been analyzed further.

[1] The Wind Energy Areas of Massachusetts, Rhode Island and North Carolina Wilmington East and West are located in a greater distance of 250 nm traveled on shipping routes from the measuring point Virginia's Hampton Roads Tunnel Bridge.

2. Criteria Set – Manufacturing requirements

Initial screening (1st tier screening)

Ports have to meet a minimum set of criteria to be considered of potential use to set up offshore wind manufacturing facilities.

The study reviewed the ports capability to potentially set up manufacturing facilities for

- blades,
- nacelles,
- tower,
- jacket foundation,
- generators, and
- sub-marine cable manufacturing and load out.[2]

Initially we screened for a potential regional *super port* that could serve as a staging port and could accommodate up to two to three manufacturing functions. A super-port would require no overhead restrictions, deep water access and a specific minimum channel width and a large developed terminal area to accommodate two to three manufacturing functions. However our research has shown that no port exists within the geographical area that would meet the criteria for a super port.

All of those six manufacturing activities listed above have a set of minimum requirements in common. The following table lists the minimum criteria which would have to be met by all offshore wind manufacturing types in order to set up their manufacturing facility.

Table 2 Minimum requirements for all offshore wind manufacturing facilities

- Channel depth of more than 5 m (16')
- Vertical clearance of 20 m (65')
- Horizontal clearance of 25 m (82')
- Terminal site with continuous area of 24 acres (10 ha)
- Quay length of 125 m
- developed port with water front infrastructure (quay side)

These criteria are the basis for the screening for offshore wind manufacturing capabilities of port terminals.

Furthermore the following assumptions were applied to the initial screening:

- Port business plans would need to incorporate long-term exclusive operations of Offshore Wind manufacturing at their site.
  - Port terminals with exclusive existing competing port terminal operations (i.e. oil refinery, use by the Navy or 100 % usage for warehousing needs) have not been screened further.
- Port development plans in the planning stage have not been included in the analysis.
- Recreational ports and marinas have not been screened.

[2] Generator and cable manufacturing and load-out functions were to be considered as time allows. These two activities are typically not considered as high labor and investment intense as the other activities and would not be the initial drivers for the offshore wind industry to kick off.

Port terminals whose capabilities did not meet the minimum requirements and assumptions were not analyzed further in this study.

Detailed (second tier) screening of ports that meet the minimum requirements

Second tier screening of port terminals identified in the first tier screening reviewed navigational constraints, the ports infrastructure including terminal area and quay side, and rail and road infrastructure for each of the manufacturing activities.

Second tier screening included for each port:

- Land parcel size (acreage),
- Navigational constraints,
- Waterside infrastructure (quay side, quay length),
- Infrastructure: road and rail access.

Table 3: Second tier criteria screening overview (port requirements)

	Offshore Wind activities					
Optimal criteria	Blade manufacturing	Nacelle Assembly	Tower fabrication	Jacket (support structure) fabrication	Generator manufacturing	Cable manufacturing and load out
Navigational Access criteria						
Overhead clearance	20 m (65')	20 m (65')	20 m (65')	85 m (279')	20 m (65')	30 m (98')
Horizontal clearance	25 m (82')	25 m (82')	25 m (82')	35m (115')	35m (115')	27.5 m (90')
channel depth	5 m (16') - barge or general cargo vessel	5 m (16') - barge or general cargo vessel		5 m (16') - barge or general cargo vessel *OR* heavy lift coaster vessel: 9m (32')		3-9 m draft
Port Facility Infrastructure						
Quay side pier linear length	200m	300 m	300 m	125m	200m	125m
Continuous terminal area	15 - 25 ha (37 - 62 acres)	7-10 ha (15 - 25 acres)	12 - 20 ha (30 - 50 acres)	12-20 ha (30 - 50 acres)	6 - 7 ha (15 - 19 acres)	8-9 ha (20 - 22 acres)
Ceveloped port site	applies to all					
Infrastructure						
Road and Rail Access	either rail or road; oversized trucks	either rail or road	either rail or road	either rail or road	either rail or road	either rail or road

Meeting the requirements means that the reviewed port would:

- Be accessible via vessel for incoming materials and outgoing goods (would meet navigational requirements)
- Have adequate continuous terminal area
- Have a suitable berth and quayside (length)

We have not reviewed criteria related to

- Ground bearing strength and loading capabilities
- Utility connections
- Machinery and cranes
- Suitability of buildings
- Security system in place
- Suitability of the sea bed for jacking up.

Commercial activities of ports with respect to their utilization have been reviewed on a high level to the best extent possible as information was made available.

Screening specifics

- Unrestricted deep water access shall mean a channel depth of greater than 9m.

Note on generator and cable manufacturing facilities

Generator manufacturing and cable manufacturing and load out have less minimum requirements for specific criteria than the 2nd tier screening criteria for all offshore wind activities. For example the terminal size for a generator manufactory requires typically between 6 to 7 ha (15 – 19 acres) while cable manufacturing requires a quay side of only 125 m. On this notion there are ports within the geographical scope that would meet the requirements to just serve as generator or as cable and load out manufactories.

The focus of this study whatsoever lay on identifying strong competitive ports that would have the potential to attract more than two or three manufacturing activities which would have enough momentum to pull the offshore wind industry at this location forward. Therefore no specific screening for marginal ports meeting only the requirements for generator or cable and load out manufactories has been conducted.[3]

3. Assessed ports within the geographical scope based on 1st tier screening criteria

We researched the parameters for the ports within the geographical scope based on:

- desktop research
- interviews with port owners and operators (as applicable)
- Email exchange with ports

All identified port owners and operators were given the opportunity to comment on the infrastructure of their port terminals as presented in this study.

[3] We recommend conducting an additional screening of ports within the geographical area to identify smaller terminals for generator and cable manufacturing if this is a special interest.

4. Port evaluation (2nd tier screening)

We reviewed the ports that met the 1st tier screening criteria for their suitability for each of the offshore wind activities.

We used the following grading to show the evaluation results of each terminal's suitability for each offshore wind manufacturing activity.

Table 4 Grading of port suitability for each offshore wind activity

Grade	Definition
Green	Site is suitable for offshore wind activity
Yellow	Site is suitable for activity with some minor constraints
Orange	Site is suitable for activity with some major constraints
Red	Site is unsuitable for offshore wind activity

Note on grading interpretation:

Assessments of the port facilities are based on optimal conditions for the manufacturing layout. While green has a "go" and red a "no go" meaning, the grading of yellow and orange shows steps in between. A grading of yellow indicates that the activity might be conducted with some minor constraints whereas a grading of orange indicates that a large compromise would need to be made when using the specific site.

Screening results

1. Screened ports within the geographical scope

The screening analysis for ports to meet the minimum requirements for blades, nacelles, tower and jacket foundation manufacturing facility needs is applied to ports from Massachusetts to North Carolina (with exception of Wilmington, NC which is located further than 250 nm from the Kitty Hawk WEA). Ports in Virginia were not screened since they do not compete with Virginia's ports already identified and assessed for offshore wind manufacturing operations (report 1).

Within the 250 nm geographical area from the closest to the furthest WEA that Virginia's ports could serve (WEA NC Kitty Hawk to WEA NY) competing regional ports were screened. The following table lists the estimated travel distance from the screened ports to each of the Wind Energy Area within 250 nm.

<u>Results of the initial screening</u>

Table 5 Estimated Travel Distance from Screened Ports to Wind Energy Areas within 250 nm

	Estimated Distance from Ports (nm) to Wind Farm Area (WEA)								
Wind Energy Area (WEA)	Norfolk, VA	Philadelphia, PA	Penn Terminal, PA	Paulsboro, NJ	Wilmington, DE	Baltimore, MD	PANYNJ	Quonset Point, RI	New Bedford, MA
New York WEA	250	210	199	204	187		19	145	157
New Jersey WEA	185	138	127	132	116		89	196	207
Delaware WEA	143	92	82	87	75		121	243	
Maryland WEA	120	118	107	112	95		135		
Virginia WEA	30	209	198	203	186	170			
North Carolina Kitty Hawk WEA	74	241	230	235	218	215			

Notes:

- The routes were measured based on general navigation principles using shipping lanes including traffic separation schemes.
- The travel distance to the WEA's was measured from the Hampton Roads Tunnel Bridge central point for Norfolk, VA, Walt Whitman Bridge center point for the ports of Philadelphia, the Verrazzano-Narrows Bridge center point for ports in New York and New Jersey (PANYNJ), the Francis Scott Key Bridge for Baltimore ports, and the New Bedford Hurricane Barrier center point for New Bedford.
- The distance was measured to the North-Western point of each of the WEAs and in case of New Jersey's WEA to its center point.
- Red signals a travel distance further than 250 nm.

The following major industrial ports were excluded from the screening due to their location outside of the geographical distance of 250 nm from the identified WEA's:

- Portland, Maine
- Boston, MA
- Wilmington, NC
- Georgetown, SC
- Charleston, SC
- Savannah, GA
- Brunswick, GA
- Jacksonville, FL

Ports outside of the geographical scope have not been included in the analysis.

2. First tier screening
- minimum requirements for offshore wind manufacturing -

Ports within the geographical scope were screened for the criteria identified as minimum requirements for each of the six manufacturing activities considered, such as blades, nacelles, tower and jacket foundation manufacturing facilities.

First tier screening reviewed navigational access criteria for vessels entering and exiting the port, the ports infrastructure including quay and terminal site.

Navigational access criteria

The vessels that would access the port facility dictate the waterside infrastructure requirements. The first tier screening took a more general approach at the ports' accessibility via vessel. We took into account the use of general cargo vessels and tug and barges. Jack up vessels would be the preferred option for jacket foundation manufacturing while cable lay vessels would be used when operating a submarine cable manufactory. Screening details of specific vessel types were applied in the 2nd tier screening.

For the initial analysis we considered that the port would need to be accessible by a general cargo vessel or a tug and barge at a minimum. Vessel requirements are laid out in detail in report 1 of the Port Readiness Evaluation for DMME.

Port facility infrastructure and rail and road infrastructure

Components are brought in to the facility either by sea, rail or road and are exported via vessel out to the offshore wind site.

The dimensions and type of materials and components imported and manufactured in the facility pose specific requirements to storage, laydown areas and the manufactory layout itself. Suitable continuous storage areas meeting the heavy load requirements are crucial.

The BVG consulting team has developed port requirements for each of the manufacturing facility types. Report 1 lists ideal port characteristics for each of the offshore wind facilities including required terminal areas and rail and road access.

Parameter for 1st tier screening

The regional port analysis takes the navigational and infrastructural requirements into account on a high level basis. The following criteria set has been developed to meet at a minimum the requirements for one offshore wind manufacturing activity.

The first tier screening includes the minimum parameter listed in table 2 and shown below.

Minimum requirements for all offshore wind manufacturing facilities:

- Channel depth of more than 5 m (16')
- Vertical clearance of 20 m (65')
- Horizontal clearance of 25 m (82')
- Terminal site with continuous area of 24 acres (10 ha)
- Quay length of 125 m
- developed port with water front infrastructure (quay side)

First tier port screening results

Seventeen ports within the geographical scope meet the minimum requirements for offshore wind manufacturing.

Ports meeting the first tier screening are:

- Port of Philadelphia, PA:
  - Packer Avenue Terminal
  - Tioga Terminal
- Penn Terminal, Eddystone, PA
- Paulsboro Marine Terminal, NJ
- Port of Wilmington, DE
- Port of Baltimore, MD:
  - Seagirt Terminal
  - Dundalk Terminal
  - Masonville / Fairfield Auto Terminal
  - AMPORT Auto Terminal
  - Sparrows Point Terminal
- Port of New York and New Jersey:
  - Staten Island Global Container Terminal, New York
  - Bayonne Global Container Terminal, New Jersey
  - APM Terminal, New Jersey
  - Maher Terminal, New Jersey
  - Port Newark Container Terminal, New Jersey
- Quonset Point / Davisville, RI
- New Bedford, MA

These ports could serve the offshore wind project areas identified in the geographical scope and would potentially compete with Virginia's ports. The following chapter provides some background on the infrastructure of these 17 port terminals.

Ports that did not meet the first tier screening

The following is a list of ports that did not meet the 1st tier screening criteria.

Table 6: Ports not meeting the first tier screening criteria

Excluded ports (1st tier screening)	Reason for exclusion
Camden, NJ (Broadway and Beckett Terminal)	not enough continuous laydown area; terminal layout not compatible with lifting of large and heavy offshore wind components (**maneuverability** issues);competing existing business
Gloucester City, NJ	usable quay side too small; terminal layout (warehouses) incompatible with minimum requirements; competing existing business
Edgemoor, DE	existing oil refinery
Gibbstown, NJ	no developed port site; former DuPont Chambers plant; cleanup by USACE; plans for development in initial stages
Westville, NJ	existing oil refinery; no port infrastructure
Marcus Hook, DE	existing oil refinery
Delaware City, DE	existing oil refinery with no quay side
Annapolis, MD	in use by US Navy; shallow navigational access and small port terminal
Morgantown / Newburg, MD	no developed port site; electricity generating facility
Piney Point, MD	no developed port site, oil & gas jetty
Cambridge, MD	recreational harbor
Artificial Island, DE (Salem Nuclear Power Plant)	no developed port site and facilities
Salem River, NJ	terminal area too small; shallow draft port
Washington, DC	no industrial developed port site
Atlantic City, NJ	no industrial developed port site
Ocean City, NJ	no industrial port; shallow fishing port
North Locust Point, Baltimore, MD	terminal area too small
South Locust Point, Baltimore, MD	terminal area too small; terminal layout incompatible; warehouses directly at quay
Intermodal Container Transfer Facility (ICTF), Baltimore	layout and operation incompatible (rail tracks; intermodal transportation)
Rukert Terminal, Baltimore, MD	continuous terminal area too small
Red Hook Container Terminal, Brooklyn, NY	continuous usable terminal area too small
Cianbro Corporation, Baltimore, MD	terminal area too small
Perth Amboy, NJ	existing oil refinery
Port Johnston, NJ (Constable Hook)	former tank farm; remediation ongoing; future development unclear
New Haven CT	continuous usable terminal area not large enough
New London, CT	continuous usable terminal area not large enough
Bridgeport, CT	quay side length too short; remaining port side not developed
Providence, RI	usable terminal size too small
Fall River, MA	Usable terminal size too small
Morehead City, NC	limited usable terminal area; warehouses take up entire quay side

3. Results from 2nd tier screening – Port Evaluation

This section represents the findings from our evaluation of Seventeen port terminals. We reviewed each of the 17 ports derived from the first tier screening for their suitability for each of the offshore wind activities listed below.

The following 17 ports could potentially compete with Virginia's ports for serving the WEA areas and being used as an offshore wind port:

- Port of Philadelphia, PA (2 terminals)
- Penn Terminal, Eddystone, PA
- Paulsboro Marine Terminal, NJ
- Port of Wilmington, DE
- Port of Baltimore, MD (5 terminals)
- Port of New York and New Jersey (5 terminals)
- Quonset Point / Davisville, RI
- New Bedford, MA

This section provides information on each of the 17 port terminals:

a) Background on its infrastructure including the land parcel size (acreage), navigational constraints, waterside infrastructure (quay side, quay length), road and rail infrastructure and commercial activities (as available, compare Table 3).

b) Assessment of its capability to serve the following offshore wind activities – 2nd tier screening:

   - Blade manufacturing
   - Nacelle assembly
   - Tower manufacturing
   - Jacket foundation manufacturing
   - Generator manufacturing
   - Submarine cable manufacturing and load out

The screening took into account the existing port layout.
The findings of the screening are accompanied by an aerial picture of the port terminal.

It can be noted that particularly for jacket foundation manufacturing more stringent criteria apply for overhead restrictions.

<u>Detailed results from second tier screening for each of the port terminals</u>

Port of Philadelphia

The port of Philadelphia encompasses three terminals which (will) provide suitable conditions and continuous access to the terminal site from the water front: Packer Avenue Marine Terminal, Tioga Terminal and the planned Southport Marine Terminal adjacent to the Packer Terminal.[4]

Packer Avenue Marine Terminal (Philadelphia, PA)

Philadelphia's Packer Avenue Marine Terminal is a state owned port on the Delaware River just downstream of the Walt Whitman Bridge. It is a premier container handling facility used for refrigeration and project shipments. Storage and laydown area is available in the vicinity of the quay side area and mostly maneuverable. A few warehouses (dry and refrigerated) exist which are not deemed usable for offshore wind manufacturing due to their current use. Deepwater vessel access and access via on-dock rail and road is given. However, overhead restrictions through the Delaware and Commodore Berry bridges do not allow for jacket foundation manufacturing.

The terminal site is large enough for one larger size manufactory (tower or blade manufactory) or potentially two smaller size manufactories such as nacelle or generator or cable manufacturing.

<u>Commercial considerations:</u>

Packer is a busy and robust existing terminal. Offshore wind manufacturing does not appear to be in the terminals current business plan.

Local workforce is in place.

Table 7 provides an overview of the port. Table 8 summarizes the evaluation. Figure 1 shows an aerial photograph of the site.

[4] The Southport Marine Terminal has not been screened as the development is still in its planning phase.

Table 7 Overview of Packer Avenue Marine Terminal (Philadelphia, PA)

Category	Comments
Location	Downstream of Walt Whitman Bridge Delaware River at Packer Avenue in Philadelphia
Size (Acreage)	450,000 m^2 (45 ha, 112 acres); usable area: 61 acres (24 ha)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 57 m (Delaware & Commodore Berry bridges)
Commercial overview	Publicly owned. Privately operated. Several warehouses on site. Premier container handling facility on Delaware River. Occupied by container, refrigeration and project shipping operations. Site currently occupied trough container business.
Infrastructure	Rail (CSX, Norfolk) and Highway access (I-95, I-76)
Quay length	In total 3,800 linear feet (1,158 m); continuous: 3,100 (945 m)
Strengths	Terminal area is well accessible throughout with no maneuverability issues.
Insights	Recent investments in infrastructure and security; Delaware Canal is currently deepened from 40' to 45' (12.2 to 13.7 m);

Table 8 Capability assessment of Packer Terminal for different offshore wind activities

Activity	Key Statement: Packer Terminal (Port of Philadelphia, PA)
Blade manufacturing	No site exclusivity (one larger manufactory such as blade or tower manufactory)
Nacelle assembly	No site exclusivity. (up to 2-3 smaller manufactories)
Tower fabrication	No site exclusivity. (one larger manufactory such as blade or tower manufactory)
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity. (up to 2-3 smaller manufactories)
Cable manufacturing	No site exclusivity. (up to 2-3 smaller manufactories)

Figure 1 Aerial Photograph of Philadelphia's Packer Avenue Terminal

Tioga Marine Terminal (Philadelphia, PA)

Philadelphia's Tioga Marine Terminal is a state owned port on the Delaware River just downstream of the Betsy Ross Bridge. It is Philadelphia's largest marine terminal handling containers, break-bulk cargo including ro-ro, heavy-lifts, perishables, forest products and military shipments.

Multiple warehouses are located directly at the quay side which are used for existing operations (heated, dry and cold storage) and not deemed usable for offshore wind. Storage and laydown area is only available in the north-eastern part of the terminal and behind the warehouses along the quay side. Due to their location close to the quay side the warehouses limit unloading and loading operations of blades, towers, and other large items at the terminal to the north-eastern portion of the quay and restrict their maneuverability on the site. Deepwater vessel access (10.8 m water depth @ MLLW) is given along the southern berth. On-dock and good road connections are available. However, overhead restrictions of 42 m through the Delaware, Commodore Berry and Walt Whitman bridges do not allow for jacket foundation manufacturing.

The terminal site is large enough for one smaller size manufactory such as a nacelle or generator or cable manufactory (conservative assessment).

<u>Commercial considerations:</u>

Tioga is a busy and robust existing multi-purpose terminal. Plans are underway to expand the port north of North Delaware Avenue (compare figure 2). Offshore wind manufacturing does not appear to be in the terminals current business plan.

Local workforce is in place.

Table 9 provides an overview of the port. Table 10 summarizes the evaluation. Figure 2 shows an aerial photograph of the site.

Table 9 Overview of Tioga Marine Terminal (Philadelphia, PA)

Category	Comments
Location	Directly downstream of Betsy Ross bridge; Delaware River at Castor Avenue in Philadelphia
Size (Acreage)	470,000 m^2 (47 ha, 116 acres), usable area: ~32 acres (13 ha) (behind warehouses)
Navigational constraints	Unrestricted deep water access along southern quay; overhead restrictions of 42 m (Delaware, Commodore Berry & Walt Whitman bridges)
Commercial overview	Publicly owned. Privately operated. Largest marine terminal of the Philadelphia Regional Port Authority. Robust, existing multi-purpose facility handles containers, break-bulk cargo incl. ro-ro, heavy-lifts, perishables and forest products Multiple ware houses on site directly at the quay. Occupied by robust container and project shipping operations.
Infrastructure	Rail (CSX, Norfolk) and Highway access (I-95, I-76)
Quay length	3,172 continuous linear feet (967 m)
Weaknesses	Warehouse location adjacent to the quay side restricts maneuverability to the north-eastern terminal portion.
Insights	Recent investments in infrastructure and security; Delaware Canal is currently deepened from 40' to 45' (12.2 to 13.7 m); plans for future port expansion north of Delaware River Avenue

Table 10 Capability assessment of Tioga Terminal for different offshore wind activities

Activity	Key Statement: Tioga Terminal (Port of Philadelphia, PA)
Blade manufacturing	Terminal area too small (conservative measurement)
Nacelle assembly	No site exclusivity. Potentially maneuverability issues due to limited waterfront quay side suggests yellow
Tower fabrication	Terminal area too small (conservative measurement)
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity. Potential maneuverability issues due to limited waterfront quay side –suggests yellow
Cable manufacturing	No site exclusivity. Potential maneuverability issues due to limited waterfront quay side suggests yellow

Figure 2 Aerial Photograph of Philadelphia's Tioga Terminal

Penn Terminal (Eddystone, PA)

Eddystone's Penn Terminal is a privately owned and operated port on the Delaware River 6 miles southeast of Philadelphia, PE. It is a multi-purpose facility handling containers, break-bulk cargo, perishables and project cargo such as heavy-lifts, blades and pipes.

Storage and laydown area is available adjacent to the quay side area and mostly maneuverable. Warehouses for dry and refrigerated articles exist. Deepwater vessel access (12.2 m water depth @ MLLW; 13.7 m after build out) and access via rail and road is given. However, overhead restrictions of 57 m (Delaware Memorial Bridge) do not allow for jacket foundation manufacturing.

Continuous usable terminal area south of the dry warehouses (~29 acre) would allow for one smaller size manufactory such as a nacelle or generator or cable manufactory.

Commercial considerations:

Penn Terminal seems to be a flexible multi-purpose terminal which has expressed interest in additional project activities.

Local workforce is in place.

Table 11 provides an overview of the port. Table 12 summarizes the evaluation. Figure 3 shows an aerial photograph of the site.

Table 11: Overview of Penn Terminal (Eddystone, PA)

Category	Comments
Location	Delaware River at 1 Saville Avenue, Eddystone, PA (6 miles SE of Philadelphia, PA)
Size (Acreage)	283,000 m^2 (28.3 ha, 71 acres); usable continuous terminal: 29 acres (12 ha)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 57 m (Delaware, Commodore Berry bridges)
Commercial overview	Privately owned and operated. Multi-purpose facility handles containers, break-bulk cargo, perishables and project cargo including heavy-lift cargo (i.e. 200 ton generators), blades, pipes etc. Warehouses (400,000 SF; 9 acres) Operator expressed interest in additional business operations.
Infrastructure	On-dock Rail (CSX, Norfolk, Conrail) and Highway access (I-95, I-476)
Quay length	1150 linear feet (350 m)
Insights	Delaware Canal is currently deepened from 40’ to 45’ (12.2 to 13.7 m)

Table 12 Capability assessment of Penn Terminal for different offshore wind activities

Activity	Key Statement: Penn Terminal, Eddystone, PA
Blade manufacturing	Terminal area too small (conservative measurement) No site exclusivity
Nacelle assembly	No site exclusivity.
Tower fabrication	Terminal area too small (conservative measurement)
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity.
Cable manufacturing	No site exclusivity.

Figure 3 Aerial Photograph of Penn's Terminal

Paulsboro Marine Terminal, Gloucester County, NJ

(currently under construction)

The Paulsboro Marine Terminal in NJ just across the Delaware River from Philadelphia's international airport is currently being constructed. It is publicly owned and privately operated.

The first phase of the deep draft wharf is currently being built which will result in an 850' long wharf (estimated completion early 2016); the complete length of the northern wharf is designed for 1500' (457 m). On-dock rail shall be available by early 2016 as well.
The terminal will have deep water (12.2 m water depth @ MLLW), rail and highway access. Overhead restrictions of 57 m would not allow for jacket foundation manufacturing.
The multi-purpose terminal is laid out for a high ground bearing strength. Initially designed with offshore wind customers in mind, the terminal will now accommodate a steel customer on 50 acres. 100 acres are still available for development. Warehouses are currently not planned (conversation with Jay Jones, Deputy Executive Director at South Jersey Port on 05/12/15).

The terminal site which could be developed would be large enough for up to 2- 3 offshore wind manufacturing facilities i.e. blade & tower or nacelle, generator & tower.

<u>Commercial considerations:</u>

The complete site is leased to Holt Logistics. Other terminal operations than the steel slab business (manufacturer NLMK) will be developed in the near future.

Table 13 provides an overview of the port. Table 14 summarizes the evaluation. Figure 4 shows an aerial photograph of the site.

Table 13 Overview of Paulsboro Marine Terminal, Gloucester County, NJ (under construction)

Category	Comments
Location	Delaware River in Gloucester County, NJ
Size (Acreage)	610,000 m^2 (61 ha, 150 acres); available area: 40 ha (100 acres)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 57 m (Delaware, Commodore Berry bridges)
Commercial overview	Publicly owned, privately operated (Holt Logistics). The Paulsboro multi-purpose marine terminal is currently under construction; by early 2016 the 1st phase of the berth and on-dock rail shall be built. Current plans include steel slab business (NLMK; 50 acres). 100 acres are still available for development.
Infrastructure	On-dock rail; Rail (Conrail) and Highway access (I-295)

Quay length	850' (259 ml; 1st phase); 1500' (457 m; 2nd phase)
Strengths	Multipurpose terminal with high ground bearing strength: Waterfront ground bearing strength of 7.3 tonnes / m^2 [5] Initially designed with offshore wind industry in mind.
Insights	Delaware Canal is currently deepened from 40' to 45' (12.2 to 13.7 m) The completed berth will enclose parts of the water body of the Delaware River (permitting requirement). No warehouses are currently planned.

Table 14 Capability assessment of Paulsboro Marine Terminal for different offshore wind activities

Activity	Key Statement: Paulsboro Marine Terminal, Gloucester County, NJ
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity.
Tower fabrication	No site exclusivity.
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity.
Cable manufacturing	No site exclusivity.

[5] Port owners opted to reduce construction costs by designing a 7.3 t/m2 bearing capacity. Expectation is that additional load spreading techniques would be used to allow lifting and transportation of components (GL Garrad Hassan, US DOE study, Assessment of ports for OW, 2014, p. 131)

Figure 4 Paulsboro's planned Terminal (Gloucester County Brochure 2015)

Port of Wilmington, DE

Port of Wilmington is a privately owned and operated port on the Delaware River. It is a very busy multi-purpose facility handling fresh fruit and juice concentrate, ro-ro and automobile (over the auto berth located 1m offshore accessible via a pier), break-bulk cargo, dry bulk, and project cargo such as wind energy shipments.

Large storage and laydown area is available and partly reserved for project cargo such as car imports. Warehouses i.e. for cold storage and fumigation take up 1.2 Mio SF and are not deemed usable for offshore wind manufacturing.

Deepwater vessel access (10 m water depth @ MLLW) and access via rail and road is given. However, overhead restrictions of 57 m through the Delaware Memorial Bridge do not allow for jacket foundation manufacturing.

<u>Commercial considerations:</u>

Wilmington is a very busy port. Offshore wind manufacturing has been previously marketed. However, the development plans for a 60 acre site (currently used for land fill) for wind development have currently stalled. Nonetheless the port is still open for new business (conversation with John Haroldson, Manager at the Port of Wilmington, DE on April 27, 2015).

Another development plan (initial planning phase) has been noted for the County of New Castle, DE just south of the City of Wilmington (south of I-295). Plans include the creation of a 176 acre container terminal at the Riversedge industrial park. Neither this plan nor the potential development of the brownfield site have been evaluated in this assessment.

Local workforce is in place.

Port Assessment:

a) Conservative assessment: Given the busy port operations and extensive use of all available space, it is assumed that potentially <u>one manufacturing facility</u> requiring ~ 10 ha (24.7 acre) might be put forward on the terminal site (conservative thinking) such as a nacelle or generator or cable manufacturing facility.

b) Competitive assessment: port might be able to put <u>one smaller facility</u> (nacelle assembly or generator manufacturing facility) at the outside storage (next to auto berth) <u>and a larger</u> tower or blade <u>manufacturing facility</u> at the auto storage area (project cargo).

   However, this scenario would compete with the existing port business and storage practices.

Table 15 provides an overview of the port. Table 16 summarizes the evaluation. Figure 5 shows an aerial photograph of the site.

Table 15 Overview of Port of Wilmington, DE

Category	Comments
Location	Delaware River at Wilmington, DE
Size (Acreage)	1,240,000 m^2 (124 ha, 308 acres) in total; 59 acres for outside storage (project cargo)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 57 m (Delaware bridge)
Commercial overview	Privately owned and operated. Non-exclusive site use. Very busy multi-purpose port terminal w/ annual tonnage of > 6mio tons Big import terminal for fresh fruit and juice concentrate; ro-ro & automobile hub (auto and ro-ro berth); other cargo includes steel, forest products, dry bulk, petroleum, livestock, project cargo & wind energy shipments. 1,2 Mio SF of warehouse space for cold storage etc. (9 buildings)
Infrastructure	Rail (Class 1) and Highway access (I-295, I-495)
Quay length	4000 linear feet (1219 m)
Strengths	Large quay with up to 7 berths
Insights	Delaware Canal is currently deepened from 40' to 45' (12.2 to 13.7 m) Ro-ro project cargo is transported via the auto berth located 900' offshore and accessed via a 1 mile long pier 60 acre site could potentially be developed for wind manufacturing (currently land fill site with no port site).

Table 16 Capability assessment of Port of Wilmington, DE for different offshore wind activities

Activity	Key Statement: Port of Wilmington, DE ***(competitive assessment)***
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity.
Tower fabrication	No site exclusivity.
Jacket (Support structure) fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity.
Cable manufacturing	No site exclusivity.

Figure 5 Aerial Photograph of Wilmington, DE's Terminal

Port of Baltimore, MD

Seagirt Marine Terminal

Seagirt Marine Terminal is a publicly owned and operated port on the Patapsco River in Baltimore. It is a very busy container terminal.

Large storage and laydown area is available. No warehouses exist. Deepwater vessel access (12 - 15 m water depth @ MLLW) and access via on-site rail and road is given. However, overhead restrictions of 55.5 m through the William Lane Memorial and Francis Scott Key Bridge do not allow for jacket foundation manufacturing.

The terminal site would be suitable for multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out). A cluster port would be possible.

Commercial considerations:

Seagirt is a very busy container terminal. Offshore wind manufacturing does not appear to be in the terminals current business plan.

Local workforce is in place.

Table 17 provides an overview of the port. Table 18 summarizes the evaluation. Figure 6 shows an aerial photograph of the site.

Table 17 Overview of Seagirt Marine Terminal Port of Baltimore, MD

Category	Comments
Location	2600 Broening Highway, Baltimore at Patapsco River
Size (Acreage)	1,120,000 m^2 (112 ha, 248 acres)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 55.5 m 182' (William Lane Memorial and Francis Scott Key)
Commercial overview	Publicly owned, privately operated. Non-exclusive site use. Very busy (exclusive) container terminal. No warehouses on terminal site
Infrastructure	Onsite Rail and Highway access (I-695, I-95, within 2 miles)
Quay length	2552 linear feet (686.4 m)
Strengths	Large terminal
Insights	Manufacturing may conflict with existing business operations.

Table 18 Capability assessment of Seagirt Marine Terminal for different offshore wind activities

Activity	Key Statement: Seagirt Marine Terminal, Baltimore, MD
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 6 Aerial Photograph of Seagirt's Terminal

Dundalk Terminal

Dundalk Marine Terminal is a publicly owned and operated port on the Patapsco River in Baltimore. It is a very busy and versatile general cargo terminal.

Large storage and laydown area totals 552 acres (223 ha) without warehouses. Ten warehouses i.e. for packaging exist (18 acres). Deepwater vessel access (11 -12.5 m water depth @ MLLW) and access via on-site rail and road is given. However, overhead restrictions of 55.5 m through the William Lane Memorial and Francis Scott Key Bridge do not allow for jacket foundation manufacturing.

The terminal site would be suitable for multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out). A cluster port would be possible.

Commercial considerations:

Dundalk is a very busy cargo terminal consisting of container, break-bulk, automobile storage and, ro-ro. Offshore wind manufacturing might likely compete with the terminals current business plan.

Local workforce is in place.

Table 19 provides an overview of the port. Table 20 summarizes the evaluation. Figure 7 shows an aerial photograph of the site.

Table 19 Overview of Dundalk Terminal, Port of Baltimore, MD

Category	Comments
Location	2700 Broening Highway, Baltimore at Patapsco River
Size (Acreage)	2,306,700 m^2 (230 ha, 570 acres); usable size: 552 acres (223 ha)
Navigational constraints	Unrestricted deep water access; overhead restrictions of 55.5 m (182', William Lane Memorial and Francis Scott Key)
Commercial overview	Publicly owned, privately operated. Non-exclusive site use. General cargo terminal; 112,000 sf of warehouses (2.5 acres)
Infrastructure	Onsite Rail and Highway access (I-695, I-95, within ~2 miles)
Quay length	3791' (1155 m); 4080' (1,243 m); 2874' (876m)
Strengths	Large site
Insights	Manufacturing may conflict with existing business operations.

Table 20 Capability assessment of Dundalk Marine Terminal for different offshore wind activities

Activity	Key Statement: Dundalk Marine Terminal, Baltimore, MD
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 7 Aerial Photograph of Dundalk's Terminal

Sparrows Point Terminal, Sparrows Point near Baltimore, MD

(Assessment based on the existing port terminal infrastructure)

Sparrows Point is a privately owned site on the Patapsco River in Baltimore. Most of the 3,100 acre site is in hand of Sparrows Point LLC; Sparrows Point Shipyard owns 150 acres on the north-west portion of the site. Kinder Morgan has a long-term lease for 100 acres of the site. They are using the southerly berth with turning basin for unloading and loading of bulk. (Conversation with Anne Shelley, Kinder Morgan on May 20, 2015). Kinder Morgan formerly ran the Bethlehem Steel mill at Sparrows Point which was decommissioned. The site has been in use by steel manufacturers over the last 125 years and is currently cleaned up and redeveloped. Plans for the site include the development of a major multi modal distribution hub. Since the site is large, exclusivity should not be an issue as long as access to the quay side is granted to the developer.

Current vessel access to the westerly berths (pier 1-4) is restricted to barges due to shallow depths; the southerly berth might be accessed through coaster vessels via Sparrows Point channel and turning basin. However with a width of ~230 m Sparrow Point Channel's turning basin may limit the maneuverability for larger vessels. Barge service might be suggested at the current stage. Great rail and road access (I-695) are given.
The site stretches over a very large area. The port infrastructure seems to be aging. The status of the existing berths and finger piers on the western part suggests infrastructure improvements and upgrades. The portion owned by Sparrows Point Shipyard includes a drydock.
Sparrows Point Shipyard has plans to refurbish their existing piers however this would not include improvements to the ground bearing strength at this time (Conversation with Tim Barletta, Sparrows Point Shipyard on May 18, 2015).
The site would be capable to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out). However larger investments in the infrastructure than currently planned would be needed.
Table 21 provides an overview of the port. Table 22 summarizes the evaluation. Figure 8 shows an aerial photograph of the site.

Table 21 Sparrows Point Terminal, Sparrows Point near Baltimore, MD

Category	Comments
Location	Sparrows Point, Wharf Road, Baltimore at Patapsco River
Size (Acreage)	12,542,000 m^2 (1254.2 ha, 3100 acres), currently in process of redevelopment
Navigational constraints	Shallow existing berths on western side; limited maneuverability in Sparrow Point channel berth suggest barge service; overhead restrictions of 55.5 m 182' (William Lane Memorial and Francis Scott Key)

Commercial overview	Privately owned by 2 owners: Sparrows Point LLC (SP, 3100 acres) and Sparrows Point Shipyard (150 acres) Kinder Morgan has long-term lease from SP and uses the turning basin. Site is currently partly being cleaned up and redeveloped SP's plans include ideas for a major multi modal distribution hub
Infrastructure	Onsite Rail and Highway access (100 miles of onsite tracks with access to 2 class I railroads)
Quay length	Southerly berth (turning basin): ~660 m
Strengths	Very large site.
Insights	Site is in process of being redeveloped; Sparrows Point Shipyard plans to refurbish their piers Existing drydock at Sparrows Point Shipyard site Infrastructure is aging; Westerly berths are finger piers Plans for development are preliminary Only barge service at this point due to shallow westerly berths and maneuverability issues (southerly berth)

Table 22 Capability assessment of Sparrows Point Terminal for different offshore wind activities (based on existing infrastructure)

Activity	Key Statement: Sparrows Point, Baltimore, MD
Blade manufacturing	• Concerns about aging infrastructure • Limited maneuverability (Sparrow Point Channel access)
Nacelle assembly	• Concerns about aging infrastructure • Limited maneuverability (Sparrow Point Channel access)
Tower fabrication	• Concerns about aging infrastructure • Limited maneuverability (Sparrow Point Channel access)
Jacket fabrication	• Precluded due to overhead restrictions
Generator manufacturing	• Concerns about aging infrastructure • Limited maneuverability (Sparrow Point Channel access)
Cable manufacturing	• Limited maneuverability (Sparrow Point Channel access)

Figure 8 Aerial Photograph of Sparrow Points Terminal

Masonville / Fairfield Terminal (Baltimore, MD)

The Masonville / Fairfield Terminal is a publicly owned and privately operated (Mercedes Benz) port on the Patapsco River in Baltimore. It is a very busy ro-ro and auto-terminal.

Storage and laydown area totals 150 acres. According to Maryland Port Authority's website 61 acres are developed for the auto terminal. The Port Authority declined to confirm whether the remaining area of 89 acres would be available. Existing buildings are used for vehicle processing and may not be usable. Deepwater vessel access (12 -15 m water depth @ MLLW) via pier 4 and access to adjacent rail and road is given. However, overhead restrictions of 55.5 m through the William Lane Memorial Bridge would not allow for jacket foundation manufacturing.

Given a usable terminal site of 89 acres, 2-3 offshore wind manufacturing facilities (e.g. blades or tower and nacelles or generator or cable manufacturing and load out) could be built at Masonville.

Commercial considerations:

Masonville is a very busy ro-ro automobile terminal. It is unclear whether 89 acres would be potentially usable for offshore wind manufacturing. It is assumed that operations would compete with Mercedes Benz' current business plan.

Local workforce is in place.

Table 23 provides an overview of the port. Table 24 summarizes the evaluation. Figure 9 shows an aerial photograph of the site.

Table 23 Masonville / Fairfield Terminal, Baltimore, MD

Category	Comments
Location	Masonville / Fairfield Terminal, Baltimore at Patapsco River
Size (Acreage)	Total area of 60.7 ha (150 acres); thereof 61 acres (24.7 ha) are developed for auto terminal; potential usable area: 89 acres (not confirmed)
Navigational constraints	Only Pier 4 is a deep draft berth (14.9 m, 49') overhead restrictions of 55.5 m 182' (William Lane Memorial and Francis Scott Key)
Commercial overview	Publicly owned, privately operated. Commercial : busy ro-ro, auto terminal Non-exclusive site use.
Infrastructure	Adjacent to CSX spur and Highway access (I-895)
Quay length	254 m (832', Pier 4)
Strengths	Large site
Insights	Northern part of site was recently filled up and extended No cranes, no cargo storage sheds Manufacturing may conflict with existing business operations. The Maryland Port Administration declined to confirm the usability of additional terminal space.

Table 24 Capability assessment of Masonville / Fairfield Marine Terminal for different offshore wind activities

Activity	Key Statement: Masonville / Fairfield Marine Terminal, Baltimore, MD
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 9 Aerial Photograph of Masonville's and AmPorts Terminal (from left to right; the Masonville berth has been filled and the terminal site was extended since this picture was taken)

AMPORTS Chesapeake Terminal

AMPORTS Terminal is a privately owned and operated site on the Patapsco River in Baltimore. It is a very busy ro-ro and auto-terminal dedicated to automobile receiving and preparation.

AMPORTS owns 102 acres of land with a 195 m (640') deep-water berth. About 1 acre is used by warehouses for auto processing.[6] AMPORTS terminal has direct rail and road access. However, overhead restrictions of 55.5 m through the William Lane Memorial Bridge would not allow for jacket foundation manufacturing.

Given a usable terminal site of ~100 acres, 2-3 offshore wind manufacturing facilities (e.g. blades or tower and nacelles or generator or cable manufacturing and load out) could be operated at AMPORTs terminal.

Commercial considerations:

AmPort is a very busy ro-ro automobile terminal. It is assumed that operations would compete with AMPORTs current business plan.

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[6] According to a recent study by FUGRO, approximately 175 acres are owned or leased by AmPorts with 66 acres available and about 200 additional acres could be available for lease if needed (Fugro Consultants, Virginia Offshore Oil and Gas Readiness Study). This information was not confirmed at the time this study was finalized.

Local workforce is in place.

Table 25 provides an overview of the port. Table 26 summarizes the evaluation. Figure 9 shows an aerial photograph of the site.

Table 25 AMPORT Terminal, Baltimore, MD

Category	Comments
Location	AMPORT Terminal, Baltimore at Patapsco River
Size (Acreage)	Total area of 41 ha (102 acres)
Navigational constraints	deep water access overhead restrictions of 55.5 m 182' (William Lane Memorial and Francis Scott Key)
Commercial overview	Privately owned and operated. Commercial : busy ro-ro, auto terminal 56,400 SF (~ 1 acre) warehouses for auto processing Non-exclusive site use.
Infrastructure	Adjacent to CSX spur and Highway access (I-895)
Quay length	195 m (640')
Strengths	Large site
Insights	Manufacturing may conflict with existing business operations.

Table 26 Capability assessment of AMPORTs Terminal for different offshore wind activities

Activity	Key Statement: Masonville / Fairfield Marine Terminal, Baltimore, MD
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Port of New York and New Jersey

Numerous investments have been placed including port terminal and rail yard extensions, larger capacity cranes (Post-Panamax cranes), to upgrade the port infrastructure for larger amounts of cargo from incoming large Post-Panamax and Suez container vessels. Upgrades include channel dredging and bridge elevations. The channel has now been dredged down to 15 m (50') over most of the channel's length to the port terminals.
The Bayonne Bridge is currently being elevated to 65 m; the first phase of construction is scheduled to be complete at the end of 2016 and will allow access for post-panamax vessels as of then. For the purpose of this study the new elevation has been used.

As a side note, Port Johnston, NJ (Constable Hook) an industrial area which served as tank farm storage is currently undergoing clean up and remediation measures. Plans for its future development are unknown at this stage.

New York Global Container Terminal (Staten Island)

The Staten Island Global Container Terminal is a publicly owned and privately operated by Global Container Terminal port on the Kill van Kull River in Staten Island, New York. It is a very busy container port.

147 acres of open storage are currently used for containers. The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However, overhead restrictions of 60 m (Verrazzano-Narrows Bridge) preclude jacket manufacturing. A few warehouses are in place. The site would be large enough to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out).

Commercial considerations:

Staten Island's Global Terminal is a very busy container terminal geared towards serving post-panamax vessels. Offshore wind manufacturing might not be in the terminals current business plan.

Local workforce is in place.

Table 27 provides an overview of the port. Table 28 summarizes the evaluation. Figure 10 shows an aerial photograph of the site.

Table 27 Overview of Global's New York Container Terminal

Category	Comments
Location	300 Western Ave, Staten Island, NY
Size (Acreage)	Total area of 58 ha (187 acres), usable size: 147 acres (of open container storage)
Navigational constraints	overhead restrictions of 60 m (198', Verrazzano-Narrows Bridge)
Commercial overview	Publicly owned, privately operated. Commercial : container terminal with 412,000 SF container freight station, refrigerated warehouses and repair shop on site Non-exclusive site use.
Infrastructure	Onsite rail and Highway access (I-287, I-95)
Quay length	760 m (2500')
Strengths	Large site
Insights	Bayonne Bridge is being elevated to 215' (65 m; planned completion of phase 1 in 2016); channel deepening to 15 m (50') underway (completion estimated end of 2015); Manufacturing may conflict with existing container terminal operation

Table 28 Capability assessment of Global's New York Container Terminal for different offshore wind activities

Activity	Key Statement: Global Container Terminal Staten Island (New York)
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 10 Aerial Photograph of Global's New York Container Terminal (Staten Island)

Bayonne Global Container Terminal (New Jersey)

The Bayonne Global Container Terminal is a publicly owned and privately operated (Global Container Terminal) port in the Upper Bay in Jersey City, New Jersey. It is a very busy container port.

The terminal site consists of 167 acres of open storage currently used for containers. The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However, overhead restriction of 60 m (Verrazzano-Narrows Bridge) preclude jacket manufacturing. The site would be large enough to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out).

Commercial considerations:

Bayonne's Global Container Terminal is a very busy container terminal geared towards serving post-panamax vessels. Offshore wind manufacturing might not be in the terminals current business plan.

Local workforce is in place.

Table 29 provides an overview of the port. Table 30 summarizes the evaluation. Figure 11 shows an aerial photograph of the site.

Table 29 Overview of Global Container Terminal Bayonne, New Jersey

Category	Comments
Location	Jersey City, NJ
Size (Acreage)	Total area of 167 acres (68 ha)
Navigational constraints	overhead restrictions of 60 m (198', Verrazzano-Narrows Bridge)
Commercial overview	Publicly owned, privately operated. Commercial : container terminal, ro-ro and heavy lift No warehouses Non-exclusive site use.
Infrastructure	Near dock rail and Highway access (I-78)
Quay length	549 m (1,800')
Strengths	Large site
Insights	Terminal area was expanded from 100 acres (40 ha) to 167 acres (68 ha) in 2014; Channel was deepened to 15 m (50') Intermodal redevelopment project – Greenville Yard (new ExpressRail facility; ship to rail cargo service; construction scheduled for 2016) Only terminal in the harbor that can serve vessels traveling the Suez and extended Panama canal (Post-Panamax); strong focus on container handling Manufacturing may conflict with existing container terminal operation

Table 30 Capability assessment of Global's Bayonne Container Terminal (New Jersey) for different offshore wind activities

Activity	Key Statement: Global Bayonne Container Terminal (New Jersey)
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket (fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 11 Aerial Photograph of Global's Bayonne Container Terminal (New Jersey)

APM Terminal Elizabeth, NJ

APM's Terminal is a publicly owned and privately operated port in the Newark Bay in Elizabeth, New Jersey. It is a very busy container port.

The terminal site consists of 350 acres of open storage currently used for containers. The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However overhead restriction of 60 m (Verrazzano-Narrows Bridge) preclude jacket manufacturing. The site would be large enough to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out).

<u>Commercial considerations:</u>

APM Terminal is a very busy container terminal geared towards serving post-panamax vessels. Offshore wind manufacturing might not be in the terminals current business plan.

Local workforce is in place.

Table 31 provides an overview of the port. Table 32 summarizes the evaluation. Figure 12 shows an aerial photograph of the site.

Table 31 Overview of APM Terminal (Elizabeth, New Jersey)

Category	Comments
Location	5080 McLester Street, Elizabeth, NJ
Size (Acreage)	Total area of 350 acres (142 ha)
Navigational constraints	overhead restriction of 60 m (198', Verrazzano-Narrows Bridge)
Commercial overview	Publicly owned, privately operated. Commercial : containerized cargo; Non-exclusive site use.
Infrastructure	Near dock rail and Highway access (I-95, I-78)
Quay length	1080 m (3543'; *Reach B Middle Reach)*
Strengths	Large site
Insights	channel was deepened to 15 m (50') Manufacturing may conflict with existing container terminal operation

Table 32 Capability assessment of APM's New Jersey Container Terminal for different offshore wind activities

Activity	Key Statement: APM Container Terminal Elizabeth, NJ
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 12 Aerial Photograph of APM's New Jersey Container Terminal

Maher Terminal (Elizabeth, New Jersey)

Maher Terminal is a publicly owned and privately operated port in the Newark Bay in Elizabeth, New Jersey. It is a very busy container port.

The terminal site consists of 445 acres of open storage currently used for containers. The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However, overhead restrictions of 60 m (Verrazzano-Narrows Bridge) preclude jacket manufacturing. The site would be large enough to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out).

<u>Commercial considerations:</u>

Maher is a very busy container terminal. Offshore wind manufacturing might not be in the terminals current business plan.

Local workforce is in place.

Table 33 provides an overview of the port. Table 34 summarizes the evaluation. Figure 13 shows an aerial photograph of the site.

Table 33 Overview of Maher Terminal (Elizabeth, New Jersey)

Category	Comments
Location	1210 Corbin Street, Elizabeth, NJ
Size (Acreage)	Total area of 445 acres (180 ha)
Navigational constraints	overhead restriction of 60 m (198’, Verrazzano-Narrows Bridge)
Commercial overview	Publicly owned, privately operated. Commercial : containerized cargo Non-exclusive site use.
Infrastructure	On-site rail and Highway access (I-95, I-78)
Quay length	2 300m (7,545’, Port Elizabeth Branch Reach)
Strengths	Large site
Insights	Channel was deepened to 15 m (50’) Manufacturing may conflict with existing container terminal operation

Table 34 Capability assessment of Maher's New Jersey Container Terminal for different offshore wind activities

Activity	Key Statement: Maher Terminal Elizabeth, NJ
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 13 Aerial Photograph of Maher's Container Terminal

Port Newark Container Terminal

Port Newark Container Terminal is a publicly owned and privately operated (Ports America) port in the Newark Bay in Elizabeth, New Jersey. It is a very busy container port.

The terminal site consists of 180 acres of open storage currently used for containers. The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However, overhead restrictions of 60 m (Verrazzano-Narrows Bridge) preclude jacket manufacturing. The site would be large enough to become a cluster port and be used by multiple offshore wind manufacturing facilities (e.g. blades, nacelles, tower and generator or cable manufacturing and load out).

Commercial considerations:

Port Newark is a very busy container terminal. Offshore wind manufacturing might not be in the terminals current business plan.

Local workforce is in place.

Table 35 provides an overview of the port. Table 36 summarizes the evaluation. Figure 14 shows an aerial photograph of the site.

Table 35 Overview of Port Newark Container Terminal (PNCT), NJ

Category	Comments
Location	241 Calcutta Street, Port Newark, NJ
Size (Acreage)	Total area of 180 acres (73 ha)
Navigational constraints	overhead restriction of 60 m (198', Verrazzano-Narrows Bridge)
Commercial overview	Publicly owned, privately operated (by Ports America). Commercial : solely container handling Non-exclusive site use.
Infrastructure	On-site rail and Highway access (I-95, I-78)
Quay length	1,165 m (4,400')
Strengths	Large site
Insights	Channel was deepened to 15 m (50') Manufacturing may conflict with existing container terminal operation.

Table 36 Capability assessment of Port Newark's Container Terminal for different offshore wind activities

Activity	Key Statement: Port Newark Container Terminal (PNCT)
Blade manufacturing	No site exclusivity
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 14 Aerial Photograph of Port Newark's Container Terminal

Quonset Point / Davisville, RI

Quonset Point Development Corporation is a quasi-state agency that owns and operates the port of Davisville (Quonset Point) and the adjacent Quonset Business Park located in the Narragansett Bay in Davisville, RI. The port's diversified activities include automobile, frozen seafood and cold storage and project cargo (i.e. wind turbines and heavy equipment).

The terminal site consists of 60 acres of open storage; about 40 % of the site is under long-term lease agreements (according to Evan Matthews, conversation on May 18, 2015).[7] The site has excellent barge and heavy lift coaster access (15 m water depth @ MLLW), rail and road access. However, overhead restrictions of 59 m (Newport-Pell Bridge) preclude jacket manufacturing. Based on the currently available terminal site (under the current lease options), the site would be large enough for one offshore wind manufacturing facility such as generator, nacelle or tower manufacturing.

Commercial considerations:

The port of Davisville has recently invested in its port infrastructure and cranes.
Deepwater Wind holds options for using part of the terminal site to stage their offshore wind operations for the Block Island Wind Farm. Phase 1 of the Block Island Wind Farm will include installing monopile foundations in summer 2015.

Local workforce is in place.

Table 37 provides an overview of the port. Table 38 summarizes the evaluation. Figure 15 shows an aerial photograph of the site.

[7] Quonset Business Park has additional parcels available for development. However these are not located at the waterfront and have to be accessed via road or rail.

Table 37 Overview of Quonset Point / Davisville Terminal, RI

Category	Comments
Location	2574 Davisville Road, North Kingstown, RI at mouth of Narragansett Bay
Size (Acreage)	60 acres, usable area: ~36 acres
Navigational constraints	overhead restrictions of 59m (194') (Newport Pell bridge); channel depth of 9.75m (32')
Commercial overview	Privately owned and operated (Quonset Point Development Corp.) Commercial : automobile import (major cargo), frozen seafood and cold storage, project cargo incl. wind turbines and heavy equipment Non-exclusive site use.
Infrastructure	Onsite Rail and Highway access (I-95; via 4-lane limited access route to highway)
Quay length	366 m (1200')
Strengths	Currently handling wind turbines and heavy equipment.
Insights	125 acres are committed to automobile import Quonset Business Park adjacent to the port terminal offers parcels for lease i.e. for manufacturing.

Table 38 Capability assessment of Quonset Point, RI for different offshore wind activities

Activity	Key Statement: Quonset Point / Davisville, RI
Blade manufacturing	Available terminal area too small (under current lease options)
Nacelle assembly	No site exclusivity
Tower fabrication	No site exclusivity
Jacket fabrication	Precluded due to overhead restrictions
Generator manufacturing	No site exclusivity
Cable manufacturing	No site exclusivity

Figure 15 Aerial Photograph of Quonset Points Terminal

New Bedford, MA

New Bedford's Marine Commerce Terminal is a publicly owned multi-purpose terminal in Buzzard's Bay. It has been purposefully built to meet the needs of the offshore wind industry. Specifically the heavy duty quay side and high loading capacity of the terminal make it ideal for heavy lift activities. The main terminal site measures 21 acres. Deepwater and road access are given. No overhead restrictions apply. The use of a jack-up vessel may be precluded depending on the vessel's breadth due to horizontal restrictions from the hurricane barrier (150'). The size of the terminal does not allow larger manufacturing activities such as jacket fabrication. One smaller manufacturing activity such as nacelle, generator or cable manufacturing could be conducted.

Table 39 provides an overview of the port. Table 40 summarizes the evaluation. Figure 16 shows an aerial photograph of the site.

Table 39 Overview of New Bedford's Marine Commerce Terminal

Category	Comments
Location	16 Blackmer Street, New Bedford, MA
Size (Acreage)	115,113 sqm (28 acres) of open-storage over several parcels; main site: 21,4 acres
Navigational constraints	Channel depth of 9.1 m, horizontal clearance of 45.7 m (150'; Hurricane Barrier); no overhead restrictions
Commercial overview	Publicly owned, privately operated. potential cargo: heavy lift, project cargo, ro-ro etc. no warehouses at this point
Infrastructure	Highway access (I-195 within 2.5 miles)
Quay length	240 m (800') with 32' water depth; 122 m (400') with 14' water depth
Strengths	Multipurpose terminal developed for offshore wind activities Quay loading capacity of 60 t/sqm 304.8 m heavy duty quay side 21 acres with uniform loading capacity of 4100 PSF (20 t/m3 at main terminal) Seabed is suitable for jacking up in harbor
Weaknesses	No on-site rail currently but planned within the next 5 years
Insights	Port operator still needs to be determined.

Table 40 Capability assessment of New Bedford's Marine Commerce Terminal for different offshore wind activities

Activity	Key Statement: New Bedford Marine Commerce Terminal, MA
Blade manufacturing	Terminal area too small
Nacelle assembly	
Tower fabrication	Terminal area too small
Jacket fabrication	Precluded due to limited size of terminal area
Generator manufacturing	
Cable manufacturing	

Figure 16 Aerial Photograph of New Bedfords Marine Commerce Terminal

<table>
<tr><th>Activity</th><th>Packer Terminal (Philadelphia)</th><th></th><th>Tioga Terminal (Philadelphia)</th><th>Penn Terminal (Eddystone, PA)</th><th>Paulsboro Terminal (Gloucester Cty)</th><th>Wilmington, DE</th><th>Seagirt Terminal (Baltimore)</th><th></th><th>Dundalk Terminal (Baltimore)</th><th>Sparrows Point (Baltimore)</th><th>Masonville / Fairfield Autoport (Baltimore)</th><th></th></tr>
<tr><td>Blade manufacturing</td><td>Exclusivity</td><td rowspan="6">Manufacturing conflicts with port's business model</td><td>Terminal area too small (conservative measurement)</td><td>Terminal area too small (conservative measurement)</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td rowspan="6">Manufacturing conflicts with port's business model</td><td>Exclusivity</td><td>• Aging Infrastructure
• Maneuverability</td><td>Exclusivity</td><td rowspan="6">Manufacturing conflicts with port's business model</td></tr>
<tr><td>Nacelle assembly</td><td>Exclusivity</td><td>• Exclusivity
• Potentially maneuverability issues due to limited waterfront quay side</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td rowspan="2">• Aging Infrastructure
• Maneuverability</td><td>Exclusivity</td></tr>
<tr><td>Tower fabrication</td><td>Exclusivity</td><td>Terminal area too small (conservative measurement)</td><td>Terminal area too small (conservative measurement)</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td></tr>
<tr><td>Jacket foundation (support structure) fabrication</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td><td>Precluded due to overhead restrictions</td></tr>
<tr><td>Generator manufacturing</td><td>Exclusivity</td><td>• Exclusivity
• Potentially maneuverability issues due to limited waterfront quay side</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>• Aging Infrastructure
• Maneuverability</td><td>Exclusivity</td></tr>
<tr><td>Cable manufacturing</td><td>Exclusivity</td><td>Exclusivity
Potentially maneuverability issues due to limited waterfront quay side</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td>Exclusivity</td><td></td><td>Exclusivity</td></tr>
</table>

Activity	AMPORT Auto Terminal (Baltimore, MD)	Global Container T (Bayonne, NY)		Global Container T (New Jersey)	APM Terminal (New Jersey)		Maher Terminal (New Jersey)	Port Newark Container T (PNCT)	Quonset Point (Davisville, RI)	Marine Commerce Terminal (New Bedford)
Blade manufacturing	Exclusivity	Exclusivity	Manufacturing conflicts with port's business	Exclusivity	Exclusivity	Manufacturing conflicts with port's business	Exclusivity	Exclusivity	Available terminal area too small (under current lease options)	Terminal too small
Nacelle assembly	Exclusivity	Exclusivity		Exclusivity	Exclusivity		Exclusivity	Exclusivity	Exclusivity	
Tower fabrication	Exclusivity	Exclusivity		Exclusivity	Exclusivity		Exclusivity	Exclusivity	Exclusivity	Terminal too small
Jacket foundation (support structure) fabrication	Precluded due to overhead restrictions	Precluded due to overhead restrictions		Precluded due to overhead restrictions	Precluded due to overhead restrictions		Precluded due to overhead restrictions	Precluded due to overhead restrictions	Precluded due to overhead restrictions	Precluded due to limited terminal size
Generator manufacturing	Exclusivity	Exclusivity		Exclusivity	Exclusivity		Exclusivity	Exclusivity	Exclusivity	
Cable manufacturing	Exclusivity	Exclusivity		Exclusivity	Exclusivity		Exclusivity	Exclusivity	Exclusivity	

Table 41 Capability assessment for offshore wind manufacturing for all screened port terminals

Summary of findings

Table 41 lists the capability assessment for offshore wind manufacturing for all screened port terminals.

As concluded in the pre-screening, no port within the geographical scope of Virginia's ports meets the screening criteria for a super port. A super port would be in a position to serve as a manufacturing cluster for 3-4 manufacturing facilities and as staging port. None of the screened ports within the geographical scope meets all these requirements. Either overhead restrictions and/or insufficient terminal size preclude the screened ports from potentially evolving as a super port.

No port within the geographical scope is able to put jacket fabrication forward. Overhead restrictions or limited terminal area preclude this manufacturing type.

Based on their terminal infrastructure and navigational access criteria, eleven ports would have the potential to become manufacturing clusters for more than 2-3 offshore wind activities. One port could launch 1 to 2 offshore wind operations at their terminal site and five ports could accommodate 1 offshore wind activity (compare table 42).

Table 42 Port capability for amount of offshore manufacturing activities per terminal

Capability for number of offshore manufacturing activities	Port Terminal	Location
3 -4	Seagirt*	Baltimore, MD
	Dundalk	Baltimore, MD
	Sparrows Point	Baltimore, MD
	New York Global Container Terminal*	New York
	Bayonne Global Container Terminal*	New Jersey
	APM Terminal*	New Jersey
	Maher Terminal*	New Jersey
	Port Newark Container Terminal*	New Jersey
2-3	Paulsboro	Gloucester County, NJ
	Masonville / Fairfield (auto terminal)	Baltimore, MD
	AMPORT Auto Terminal	Baltimore, MD
1-2	Wilmington	Wilmington, DE
1	Packer Avenue Terminal*	Philadelphia, PA
	Tioga Terminal	Philadelphia, PA
	Penn Terminal	Eddystone, PA
	Quonset Point	Davisville, RI
	Marine Commerce Terminal	New Bedford, MA

*Container terminals

Most of the ports with the capability to become a cluster ports are *container ports*. These are the ports of New York and New Jersey and Baltimore's Dundalk and Seagirt terminals. Container ports typically have a business model based on a very fast turn-around of cargo. Typically containers are stored on the terminal site for a very short time before being shipped out via rail or truck to their final destinations. Most of the container terminals in New York and New Jersey do not even operate warehouses.
Optimal logistics to use the available terminal space in a timely and efficient manner result in a high revenue. This is especially important in New York and New Jersey where the real estate prices are very high. These on-call container operations are only compatible with other operations to a limited extent. Long-term leases of terminal space do not appear to match the container operation business strategy. Therefore it is assumed that - especially exclusive - container terminals would not compete for offshore wind projects. The competition from container ports with successful ongoing operations for offshore wind projects appears low.
The same stands for an overall strong business operation as is the case with Dundalk's very busy terminal.

Therefore Seagirt, Dundalk, Global's New York and New Jersey Container Terminals, APM Terminal, Maher Terminal and Port Newark Container Terminal are not deemed to be a competition for offshore wind projects although they would have the capability to accommodate a line of manufacturers.

Masonville and AMPORT could accommodate 2-3 offshore wind activities at their terminals. However, the sites, operated by Mercedes Benz and AMPORT are very busy ro-ro automobile and processing terminals.
It is assumed that offshore wind manufacturing would not be in line with Mercedes Benz' and AMPORTs current business plan. (Information about additional available terminal area at those sites which might be used for offshore wind operations has not been confirmed.)

Sparrows Point just outside of Baltimore, MD has the potential for a cluster port as well. Due to its large site, Sparrows Point would be in a good position to develop an offshore wind manufacturing line or a cluster port and could become a competition to Virginia. Used by the steel industry for the past 125 years it is currently undergoing clean up and remediation. Plans for infrastructure improvements exist for the 150 acres owned by Sparrows Point Shipyard. However, more infrastructure investments would be needed to enable the site for offshore wind manufacturing. Further development plans in that respect are unknown at this point.

However, as shown in table 5, Baltimore would only compete over two offshore wind energy areas (Virginia and North Carolina Kitty Hawk) within Virginia's geographical scope of interest. Vessels need to travel about 140 nm inland from the Hampton Roads tunnel until they reach Baltimore. As such the estimated travel distance to the Virginia WEA would be 170 nm and to the North Carolina Kitty Hawk WEA 215 nm. The travel distance from Virginia's ports lays at 30 nm and 74 nm respectively. This clearly puts Virginia in a better position to serve these projects from an economic and feasibility perspective.

The port of Paulsboro which already had been in discussion for offshore wind operations and has been designed for heavy lift operations would also be in a good position to become a cluster port. The operator, Holt Logistics however is now serving a steel customer and is focusing on ship to rail transport operations and steel handling for now. The strong political commitment for offshore wind from the New Jersey government has lessened.
However, 100 acres of the site are still available and could be developed for offshore wind

manufacturing. If this would happen, Paulsboro might become a strong competition for the port of Virginia since it could compete for all of the offshore wind projects Virginia could go after (compare table 5).

Ports with the capability of accommodating only 1 or 2 offshore wind activities are not deemed a competition to the port of Virginia. European precedence i.e. in Bremerhaven or Cuxhaven in Germany has shown that at least 2 to 3 manufacturing entities at a port are needed to develop momentum to pull the offshore wind industry forward.

Although Quonset Point, RI and New Bedford, MA have undertaken recent investments in their infrastructure that meet the offshore wind industry's requirements, their limited available terminal area would not allow for a cluster port. Therefore they are deemed as marginal competition over offshore wind projects to Virginia.

Wilmington, Penn, Packer Avenue and Tioga Terminal in Philadelphia are only seen as marginal competition to Virginia as well.

Recommendation

We recommend to watch the developments at the ports in New York and New Jersey and in Baltimore, MD and to follow the developments at Paulsboro, NJ and Sparrows Point, MD very closely. The ports of Paulsboro and Sparrows Point might become a serious competition over offshore wind projects that Virginia could go after. Notably the port of Paulsboro, NJ could be serving all of the offshore wind projects Virginia's identified ports could serve.

Furthermore, this assessment took into account basic commercial considerations for regional competition. An initial analysis compared costs for specific labor professions (i.e. hourly wages and annual wage) for each of the screened region and has shown that the wages for the welding profession, one key offshore wind manufacturing profession differ per region.

We recommend conducting a more detailed analysis of all offshore wind disciplines for the regional ports screened for this competitive analysis. This would add another level of detail to the regional capabilities and opportunities.
In addition to the cost of labor we also recommend evaluating the prices of industrial real estate for the regional ports potentially competing for offshore wind construction jobs.

With similar port capabilities those commercial factors can be seen as important differentiators for manufacturers choosing a manufactory location and would allow a more detailed view on the competitive strengths of the regional ports.

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