Kinetik Partners

Analysis of Maryland Steel Facilities for Sufficiency to Support Offshore Wind Energy Deployment

Prepared for:

State of Maryland, Maryland Energy Administration

By Pedro Guillen, Nic Wetzler, Nick Abstoss

About the Authors

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Analysis of Maryland Steel Facilities for Sufficiency to Support Offshore Wind Energy Deployment

Report completed on December 12, 2011

Kinetik Partners

Executive Summary

Creating the opportunity for Maryland's steel industry

The state government and industry have taken steps to facilitate future growth; such as enacting an aggressive RPS, engaging with key stakeholders (e.g., trade unions, employers) and studying the state's capabilities to compete in a global industry. Our conclusions are based on discussions with industry experts and our own analysis, and we present a set of recommendations to leverage public and private support.

Maryland companies have the potential to secure a large share of the steel production and fabrication required to grow the US offshore wind industry. We propose three areas of action that match the Maryland's strengths with current and future industry needs.

Steel production and fabrication

The fabrication of steel components should be the primary target for Maryland companies. While the market opportunity is substantial, so is competition due to the fact that capital requirements to enter this market are low. Therefore, policymakers should focus on large components that require long learning curves, such as specialized foundations. Additionally, the development of alternative steel supply agreements, such as aggregate buying and consignment orders, would be beneficial to take advantage of this opportunity. Lastly, developing a cluster of service operations at the Sparrows Point campus would offer a logistics advantage relative to competitors' supply sites, and thus would give Maryland steel fabricators a further advantage.

Castings

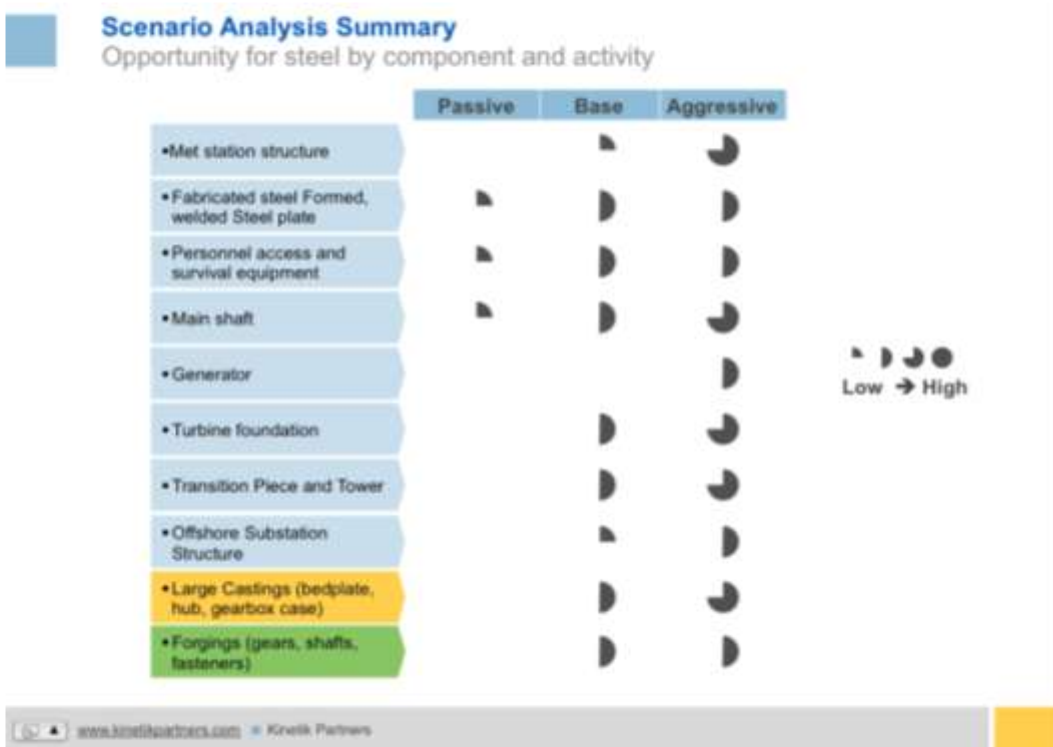
With some incremental investment, policymakers and industry should form a consortium to develop a full service foundry with onsite machining at Sparrows Point. To date, there are only three large casting facilities supplying the US wind market. None of these are competitive, mainly due to the use of old processes and lack of integrated machining on site. The integration of the latest lean manufacturing methodology with technological advances in casting and cryogenic machining could secure large market share for cast components.

Specialized Shipbuilding

Based on analysis of vessel requirements in northern Europe, we believe that achieving the US DOE's goal 10 GW installed will require the construction of a minimum of twenty-five (25) new specialized vessels. These specialized vessel prices can range between $100-150 million. The presence in Maryland of one of the seven active shipyards on the Eastern seaboard presents an opportunity to partner with a European ship designer and/or operator to secure the construction and commissioning of these specialized vessels.

Scenario Analysis: Results

Kinetik developed three scenarios based on different levels of investment to grow regional capabilities. The image below subjectively quantifies the opportunity based on capabilities and investment by component.



Passive Scenario

The passive scenario shows poor results. Assuming limited sales to potential Maryland projects and other regional projects, this path shows minimal incremental sales reaching $20 Million by 2025.

Types of components:

- Fabricated steel Formed, welded Steel plate
- Personnel access and survival equipment
- Main shaft

Base Scenario

The base scenario shows significant promise with limited investment. It is contingent upon developing a strong cluster of services at Sparrows Point including partnerships with existing offshore companies or new market entrants. Policymakers and industry should focus on developing heavy fabrication, forgings, casting and machining capability.

Within this scenario, policymakers and industry use small investments to upgrade Sparrows Point's infrastructure to attract a wide scope of offshore wind service companies. In turn, this minimizes logistics costs through co-location and ensures that the cluster is competitive. Roll forming equipment will most likely need to be acquired to execute this strategy.

Investments in small forging and coating capabilities can provide access to fastener and other existing component OEMs as a tier 3 supplier. This could be done by, or in partnership with, local companies or through the attraction of a diversified specialty fastener company.

Additionally, foundry and machining equipment could open opportunities for the development of large castings for the wind industry in small volumes

Types of components

- Met station structure
- Fabricated steel Formed, welded Steel plate
- Personnel access and survival equipment
- Main shaft
- Turbine foundation
- Transition Piece and Tower
- Offshore Substation Structure
- Large Castings (Bedplate, hub, gearbox case)
- Forgings, Gears, shafts Fasteners

This scenario could bring over $650 million by 2025 and between 3,500 to 5,000 jobs to the region.

Aggressive Scenario

The aggressive scenario shows significant market share opportunities for Maryland companies. However, it will require higher investment levels and coordination between industry players. A strong integrated cluster will need to be developed around the Sparrows Point complex providing the capability to competitively supply offshore wind components in partnership with a key offshore company and a new entrant.

The evolution of the offshore wind energy supply chain presents an entrance opportunity for Maryland companies. During early stage growth markets, OEMs tend to vertically integrate to minimize supply risk from underdeveloped portions of the supply chain. As markets mature and supply chains develop fully, OEMs tend to divest non-core assets and components to focus on core business activities. For example, Vestas has been traditionally one of the most vertically integrated OEMs. While this strategy has helped during high growth years, overcapacity in slow growth years has hurt the company financially. Today, they are looking to divest from most non-core business.

Maryland policymakers and industry should focus on securing partnerships to shift full production from an OEM-operated, vertically integrated facility to a cluster-operated site. The investment should focus on acquiring or developing competencies or acquiring divesting assets which serve heavy fabrication, forgings, casting and machining.

The aggressive scenario will require investments to upgrade the Sparrows Point's infrastructure to minimize logistics costs and increase competitiveness. Necessary infrastructure investments include docks, staging areas and enclosed fabrication facilities.

Investment in large roll forming and welding equipment will be necessary to secure significant foundation and transition piece contracts.

Foundry and machining equipment could open opportunities for the development of large castings in medium to large volumes. The addition of machining equipment could provide opportunities to fabricate large components such as generator stators and cases, as well as gear machining.

Investments in small forging and coating capabilities can provide access to other component OEMs, such as fasteners. This could be done through local companies or by attracting a specialty fastener company to the site.

Types of components:

- Met station structure
- Fabricated steel Formed, welded Steel plate
- Personnel access and survival equipment
- Main shaft
- Generator components
- Turbine foundation
- Transition Piece and Tower
- Offshore Substation Structure
- Large Castings (Bedplate, hub, gearbox case)
- Forgings, Gears, shafts Fasteners

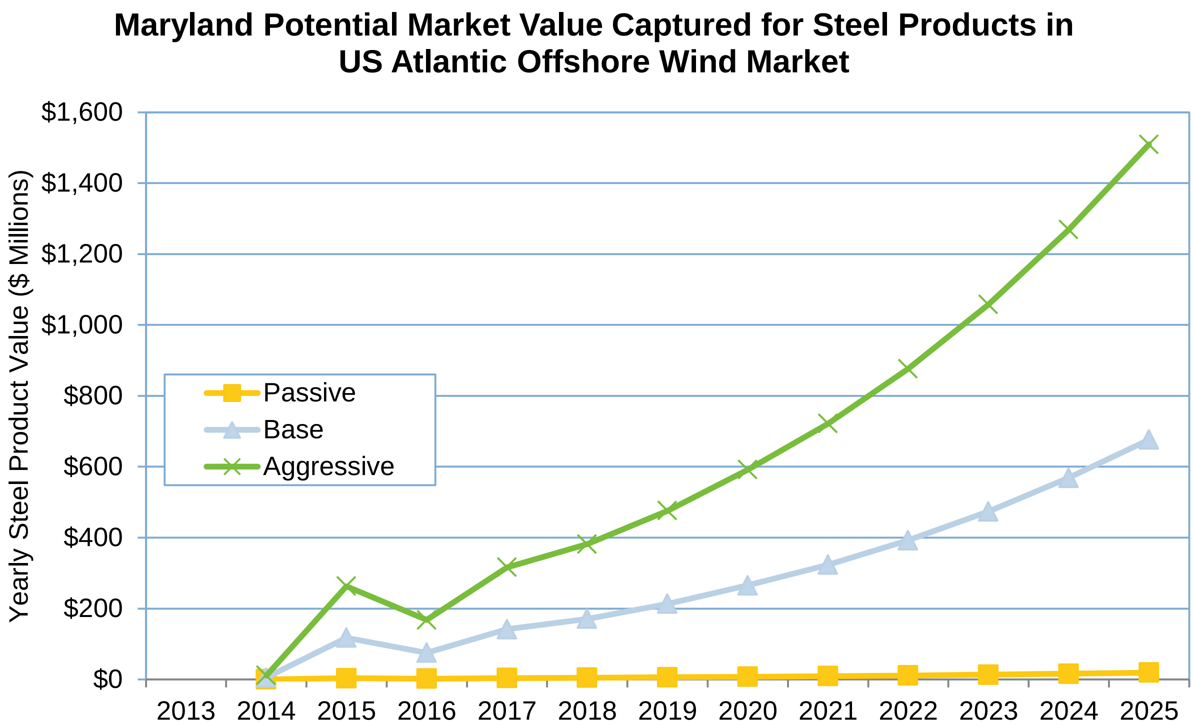
This scenario could bring over $1,500 Million by 2025 and between 6,000 to 8,500 jobs to the region.

Specialized Shipbuilding

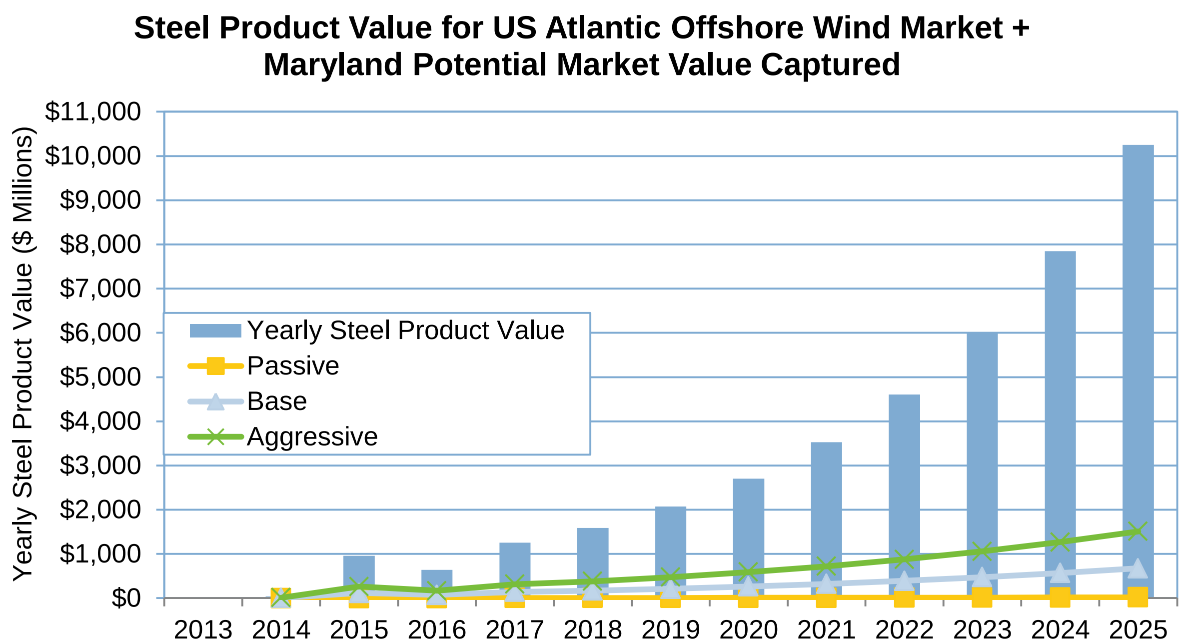
Building multiple specialized vessels would bring an additional $200-300 Million to the region.

Scenario Comparison

The chart below shows the annualized value of the opportunity for a Maryland steel cluster for each of the three scenarios.



The following chart shows Maryland's opportunity against the estimated total steel product value for offshore wind on the US East Coast. This illustrates that the aggressive scenario allows Maryland companies to capture 14% of the steel component market share, whereas the base model will reach 6% by 2025.



Actions to Maximize Value Capture

In order to take advantage of this scenario, we recommend taking the following actions and engaging the following stakeholders:

Collaboration: Any investment in Maryland's infrastructure to support the offshore wind industry will require high levels of collaboration and engagement with key stakeholders. In addition to the previously-mentioned top-target firms, it is critical to establish relationships with union and labor leadership, such as the United Steelworkers, Dockworkers, Teamsters, and Maryland state higher education and technical school organizations. These stakeholders are key to supplying the skills and talent necessary to serve the employment needs of this industry.

Investment in infrastructure: Investing in capability to build the high value components of the offshore wind value chain is the most critical action for capturing the opportunity in offshore wind. As such, it is incumbent upon the state of Maryland to support the efforts of its private firms in their development of ventures and expansion of businesses, support development of partnerships between Maryland and outside companies, or to attract outside companies in order to capture this opportunity. Our discussion of cluster development around RG Steel receives our strongest recommendation: expand the casting, platemaking, rolling and welding capabilities at Sparrows Point, along with the development of onshore assembly from the numerous wharves surrounding the area. Additionally, there is opportunity for the development of ship and barge-making capabilities in Maryland, which are specifically designed to service the offshore wind industry.

Integrated operations with RG Steel: As per our cluster discussion, RG Steel should be the anchor of any investment in offshore wind supply. RG Steel's capability to provide micro-runs in the ramp up to full production is a strong asset in developing an offshore wind steel production cluster, and its long-term capability to engage in foundry operations is a strong asset as well. In addition, Maryland has embedded machining and fabrication knowledge based on its industrial composition, which should be incorporated into development of the cluster.

Aggregation of operations at Sparrows Point: While Maryland has a handful of strong players in the steel fabrication industry, a significant number of smaller firms could positively support the growth of the industry. We propose the development of an industrial consortium or collaborative enabling the support of these firms at the consortium level. An active consortium could develop more buying power for its members through aggregated buying and economies of scope through closer ties by adjacent companies in the supply chain. This will increase business while decreasing the cost of material inputs.

Partner with European offshore wind companies: Knowledge and technology transfer from European offshore wind operations is vital to the long-term success of the US offshore wind industry. Maryland can put itself in an advantageous position by partnering with manufacturers such as Siemens, Vestas, Gamesa, Areva or Alstom to build the necessary knowledge to create the premier offshore cluster location in the US. In addition, Maryland should engage the largest operators of European offshore wind farms and connect them with large East Coast utilities and utility groups, such as the Edison Electric Institute.

Transformational projects: Develop a high visibility transformational project that would attract public and institutional attention. For example, a multi-gigawatt project to provide energy to the DC Metro area or the development of a fully functional development and validation park offshore.

Standards: Maryland should engage early with standards committees and resident industries to gain early advancement and input into the technical specifications which are required for offshore wind material, specifically steel. It is in Maryland's best interest to make sure that the requirements are both fair to its industries as well as communicated early enough for its industries to adapt to best supply practices.

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Introduction

The Maryland Energy Administration (MEA) has commissioned the "Analysis of Maryland Steel Facilities for Sufficiency to Support Offshore Wind Energy Deployment" study to understand the potential impact of the burgeoning offshore wind industry on the East Coast.

Furthermore, this analysis will focus on understanding Maryland's current steel fabrication capabilities and alignment with the requirements of offshore wind developments on the East Coast. Lastly, this analysis identifies and quantifies the economic development opportunities this nascent industry could provide to Maryland's businesses and economy.

This study is managed by Mr. Andrew Gohn, Maryland Energy Administration Senior Clean Energy Program Manager.

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GRATEFUL APPRECIATION TO PARTNERS

During this study, a number of organizations and individuals were consulted to ascertain their views on offshore wind technology and to obtain relevant supporting information. We would like to thank all those who contributed including the following:

- Shawn Kiernan, Strategic Planner, Maryland Port Administration
- Richard Hoight, Quality Assurance, RG Steel
- Jerry Nelson, Business Development, RG Steel

Objectives and Approach

Overview

In October 2011 the Maryland Energy Administration, issued a class III small procurement Request for Proposal (RFP) for the "Analysis of Maryland Steel Facilities for Sufficiency to Support Offshore Wind Energy Deployment." The Maryland Energy Administration (MEA) is an agency of the State of Maryland. MEA is authorized by State law to maximize energy efficiency, increase the use of renewable and clean energy sources, and improve the environment. MEA is also engaged in the broader issues of sustainability, climate change and alternative transportation fuels and technologies. The MEA awarded contract number 2012-03-121S1 to Kinetik Partners to complete the fore mentioned study.

Selection of Kinetik Partners

Kinetik Partners (KP) was selected to perform this study based on our knowledge and experience in the global wind energy markets, growth strategy design, and technology innovation for both public and private sector clients.

Project Scope

Kinetik will analyze the capabilities of the Maryland's steel production and fabrication to support the development of commercial deployment of offshore wind generation along the Atlantic seaboard. This study provides the results of our team's effort to collect, analyze, and present information collected from industry participants and leading European organizations and offshore clusters to identify the potential impact of the Maryland steel industry in the offshore wind industry.

The identification of Maryland steel industry capability will be compared to current industry needs and how will this support offshore wind deployment. We will look not only at current technologies but also the implication of future platform evolution. This report presents the approach, analysis and recommendations to maximize the economic development opportunity that this new industry could offer to Maryland steel production and fabrication companies.

Picture 1 Siemens AG. Lillgrund Offshore Wind Farm

Project Objectives

The objectives of this project are threefold, (1) High-level assessment of Maryland steel fabrication capabilities, (2) Offshore wind value chain analysis for steel fabricated components, (3) Analysis of the economic opportunity for Maryland business based on a reasonable steel fabrication accessible market and current forecast of mid-Atlantic offshore wind installation capacity.

The written report will include detailed appendixes or sections describing model results, model assumptions and company listings, etc… The following documents will be included in the final report:

- Exhaustive list of Maryland steel fabricators
- Offshore wind turbine systems Work Breakdown Structure (WBS) including critical information on key components
- Mid-Atlantic offshore installed capacity forecast
- Accessible market value of steel fabricated components for the mid-Atlantic region
- Model assumptions for introduction of new offshore technologies
- Economic development model assumptions.

Project Approach and Methodology

Our approach is based on our proprietary Kinetik Innovation Process (KIP™). The KIP (Figure1) is an exhaustive analysis of market drivers, product trends, enabling technologies, manufacturing processes and the capabilities of the supply chain to minimize product development risks, monetize the product/service attributes and maximize the profit from the recommended change.

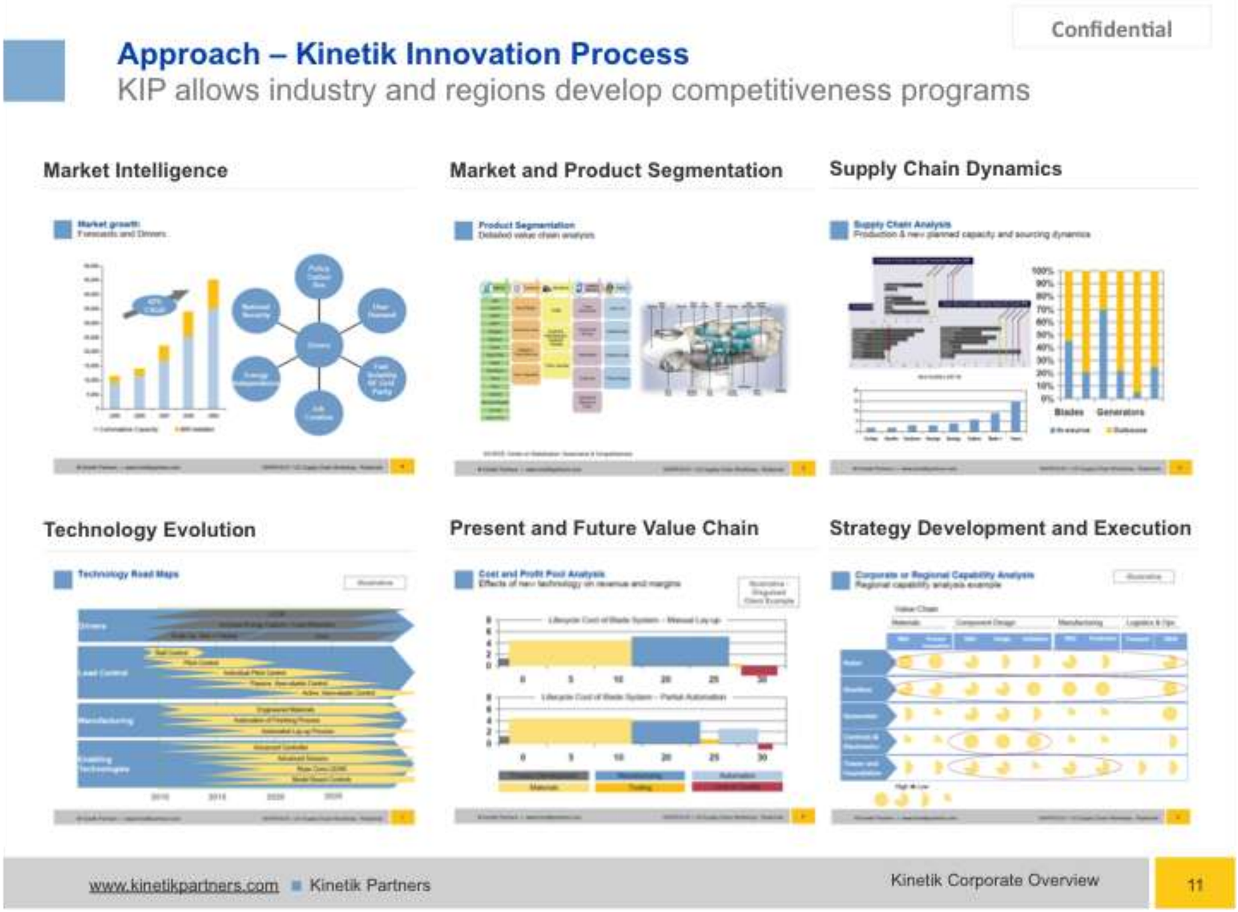


Figure 1 Kinetik Innovation Process

The KIP considers technology, financial, market and product insight to develop robust multi-generational product plans. It visualizes evolutionary and breakthrough innovation allowing our customers to develop competency enhancement plans and/or technology acquisition plans.

The KIP is a six step process to develop competitiveness programs, and provides the required inputs to develop a scenario analysis of the Maryland steel industry and analyze its ability to enter the offshore wind industry.

Step 1 Market intelligence

Step 2 Product Segmentation

Step 3 Supply Chain Dynamics

Step 4 Technology Evolution

Step 5 Economic and Value Analysis

Step 6 Regional Strategy Development

The output of these six steps will be discussed in this document. In addition, the team has included its suggestions for maximizing the economic development opportunities for the Maryland Steel production and fabrication industry.

Offshore value chain analysis for steel fabricated components

Market Intelligence

Global Market

Europe currently leads the world with cumulative installed offshore capacity of 3,000 megawatts (MW). China is the next country of note with approximately 135 MW of offshore wind capacity. The industry to date has developed mostly by adapting land-based turbines, towers, and foundations. With this evolutionary development, projects have been kept within 30 meters water depth, limiting the added complexity of marine construction and the forces of the sea. Existing oil and gas experience is readily transferrable to building wind turbines in shallow water relatively close to shore, and mature submarine power cable technology has allowed for underwater transmission networks to bring the power to land. Figure 2 shows the development of the European offshore wind industry.

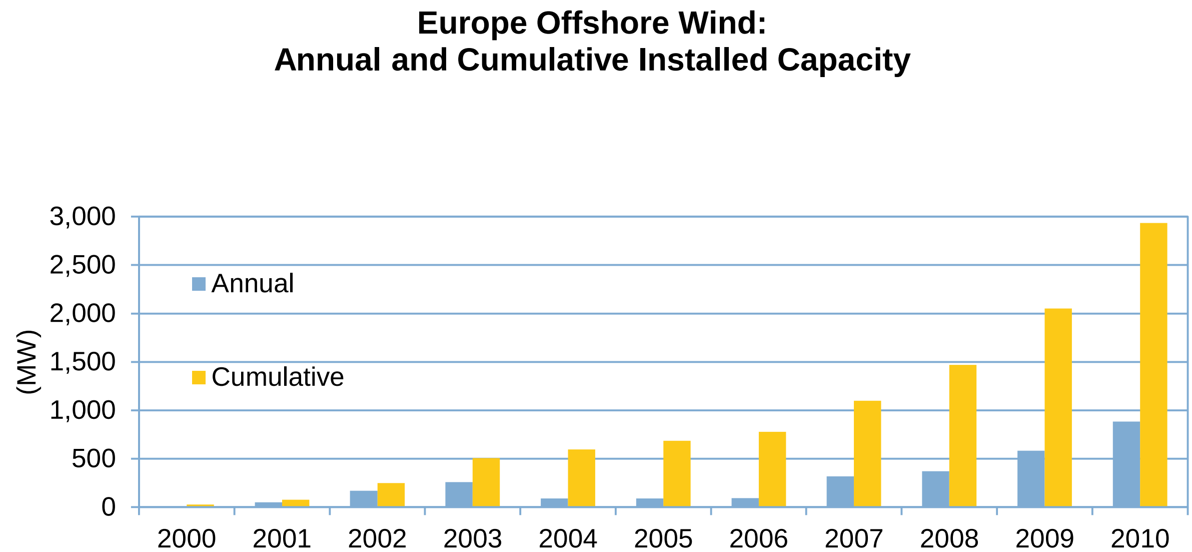


Figure 2 Europe Offshore Wind: Annual and Cumulative Installed Capacity

The first offshore projects began in 1991, mostly as demonstrations, and after a decade, only 23 MW had been installed, cumulatively. Beginning in 2000, early development was uneven. While steady year-over-year gains prevailed through 2003, the period 2004 – 2006 saw relative regression and stagnation. Turbine reliability and availability contributed to these early growing pains. Only in 2007 did the European offshore wind industry re-establish strong yearly growth that continues currently. Figure 3 compares the European onshore and offshore wind industry at similar periods of industry maturity.

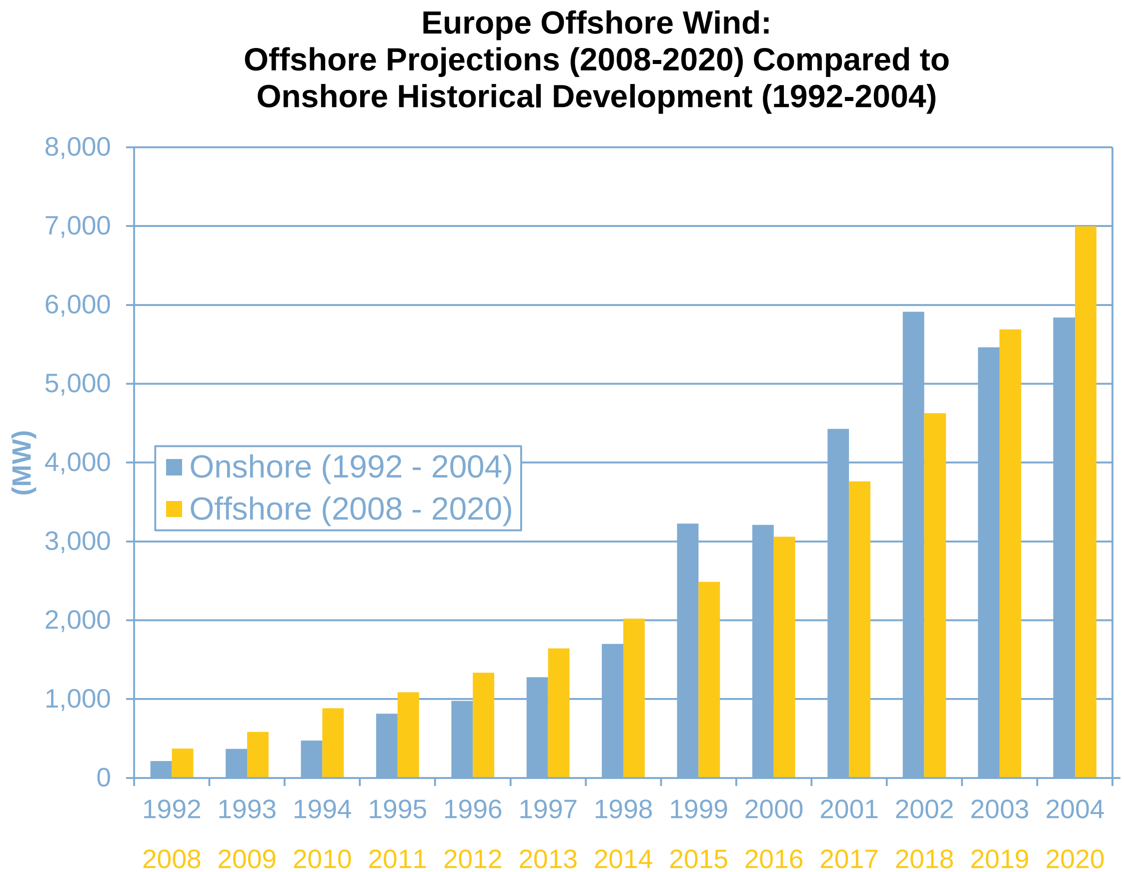


Figure 3 Europe Offshore Wind Capacity: Offshore Projections (2008-2020)

US Market

Department of Energy Goals

The US Department of Energy has set a goal to generate 54GW of offshore wind power by 2030 at a cost of $0.07 per kilowatt hour (kWh), with an interim target of 10GW by 2020 at $0.10 per kWh. To achieve these targets requires looking at new holistic concepts in turbine design that lower the current Cost of Energy (COE).

US Offshore Wind Resource Potential

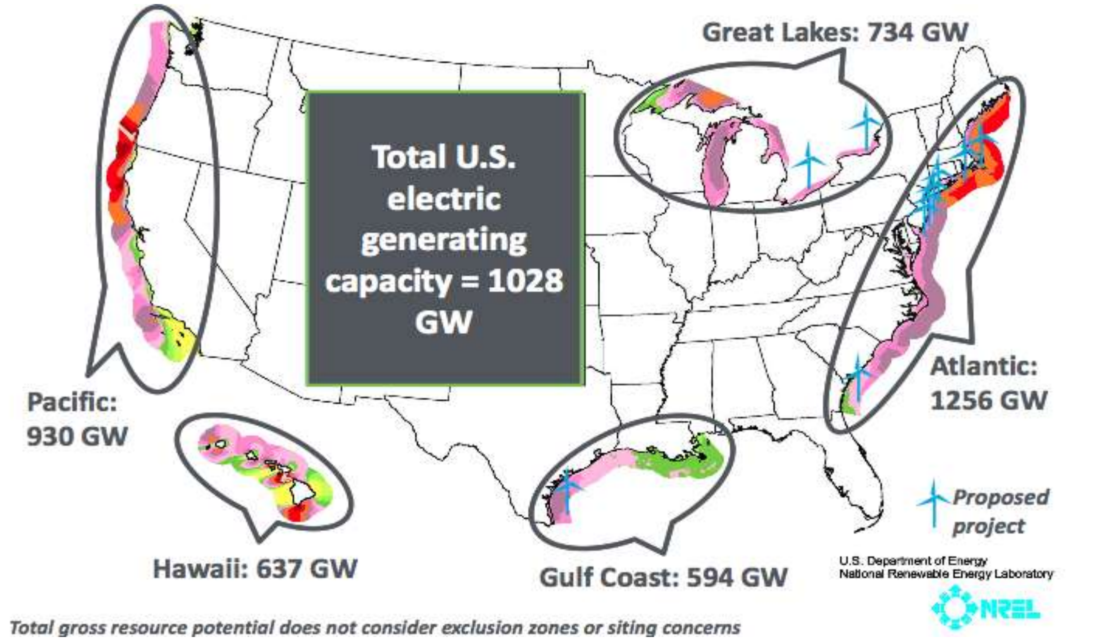
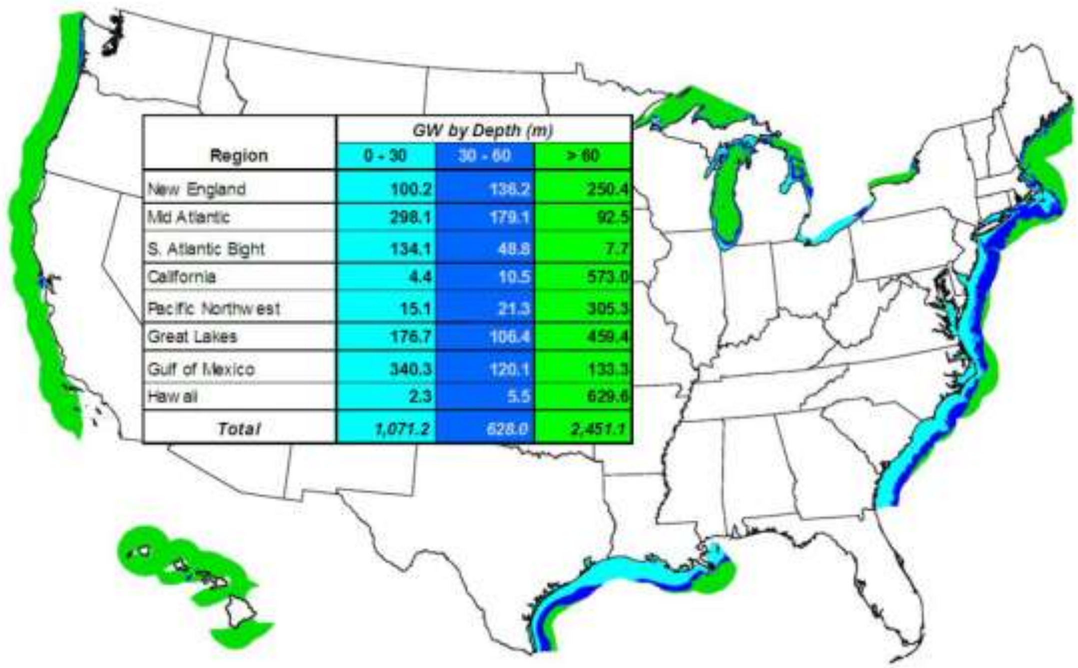


Figure 4 US Offshore Wind Resources

The United States has enormous offshore wind potential. When compared to the total US electric generating capacity of 1028 GW, the Atlantic Coast alone has enough resource to replace the entire current generating capacity of the US. While this gross resource analysis does neglect practical concerns like exclusion zones, siting concerns, and access to transmission, it clearly illustrates the opportunity presented by offshore wind. The resource is large and it is relatively close to the population centers of the US which are largely concentrated on the coasts. With 60% of the gross resource feasibly available for development, the East Coast alone could supply around 75% of the total US electrical generating capacity with offshore wind. In addition, the East Coast has a relatively shallow continental shelf, providing ample development opportunities in both the readily accessible 0-30m water depths, and also in the 30-60m water depths which are the focus of the next stage of offshore wind development. The Great Lakes and Gulf Coast also have rich opportunity in their shallow and transitional depths, while the resources of the Pacific region and Hawaii are almost exclusively greater than 60m.



Region	GW by Depth (m)		
	0 - 30	30 - 60	> 60
New England	100.2	136.2	250.4
Mid Atlantic	298.1	179.1	92.5
S. Atlantic Bight	134.1	48.8	7.7
California	4.4	10.5	573.0
Pacific Northwest	15.1	21.3	305.3
Great Lakes	176.7	106.4	459.4
Gulf of Mexico	340.3	120.1	133.3
Hawaii	2.3	5.5	629.6
Total	*1,071.2*	*628.0*	*2,451.1*

Figure 5 US Offshore Wind Resource by Water Depth

US Market Development

The European example discussed above offers important lessons as the US offshore market begins its development. Currently, there is not a single operating wind turbine in US waters, yet there is more than 8,000 MW in various stages of planning with several developers and state and local governments are vying for the ceremonial title of first turbine in the water. Kinetik's analysis of announced US projects shows that more than 1,300 MW of the project pipeline has progressed enough that construction and ultimate commissioning seems likely. While the early stages of the European offshore wind market was hindered by total market immaturity after early traction (Figure 2), indications are that the US market will reach sustained growth more easily. The global supply chain for offshore wind is more robust today than in the early 2000's when Europe was blazing the global trail for offshore wind development. In addition, the US market for wind has matured significantly with the maturation of the US onshore wind market. State renewable portfolio standards (RPS's) have been phasing in for several years, and knowledge of utility power purchase agreements and renewable integration is well understood. The US offshore wind industry will leverage European expertise in offshore wind development, as well as embedded knowledge from US development of onshore renewable energy integration and wind development.

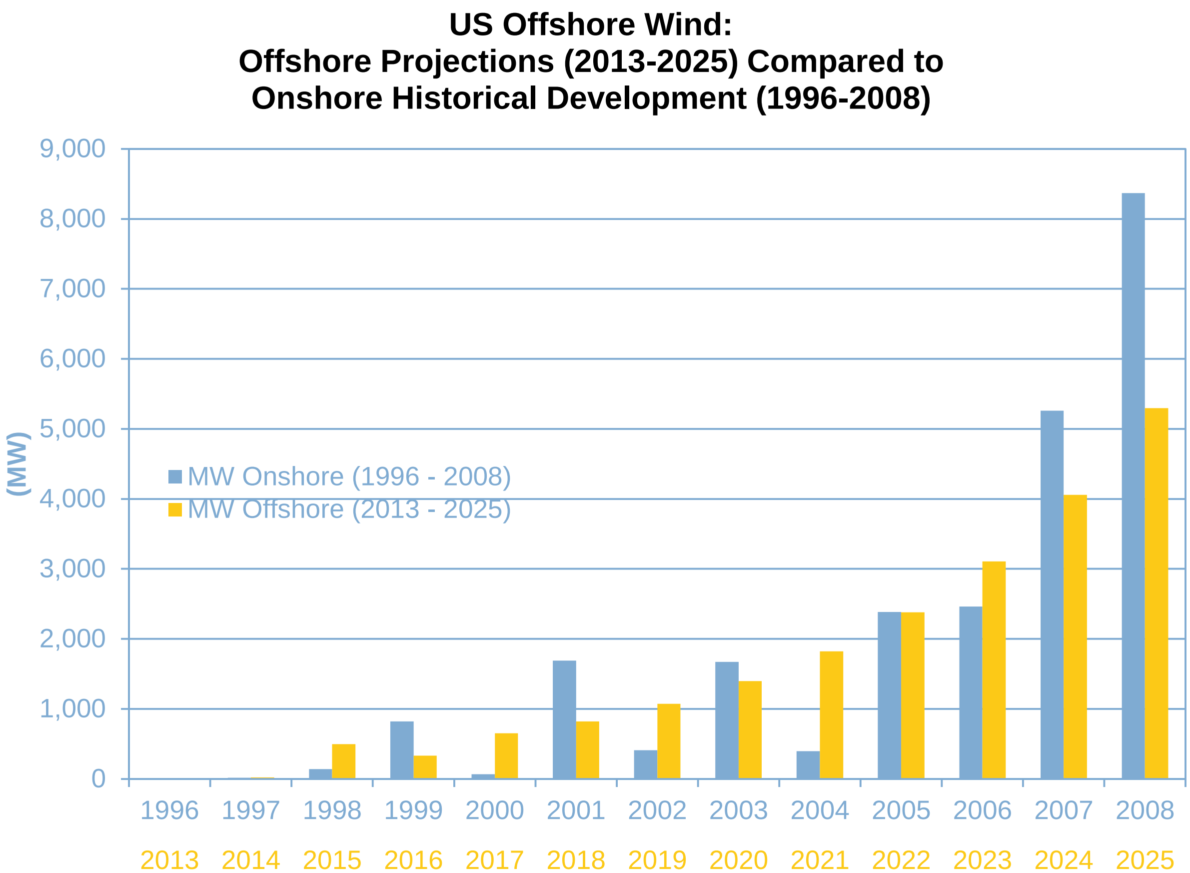


Figure 6 US US Offshore Wind: Offshore Projections (2013-2025) Compared to Onshore Historical Development (1996-2008)

Figure 6 shows the projected development of the US offshore wind industry compared to the development of the US onshore wind industry at similar periods of industry maturity. The US onshore wind market grew unevenly until 2005 due primarily to the repeated lapses and short-term re-establishment of the Production

Tax Credit for wind projects. The current offshore project pipeline in active development will come online through 2019, and states along the East Coast are actively seeking bids for development areas. Our market projection predicts nearly 5GW installed by 2020 offshore with the growth rate based on the US onshore development from 1996 through 2008.

US Market Drivers

Public Policy

All renewable energy development is still heavily driven by policy, offshore wind included. The primary policy driver has been state based RPS's requiring utilities to source a prescribed percentage of energy from renewable energy sources. The federal government has utilized economic incentives to spur renewable energy development, primarily in the form of production tax credits (PTC) and investment tax credits (ITC) to offset the costs of renewable energy facilities. As shown previously, the successive expiration and short-term renewal of the PTC incentives caused dramatic swings for US onshore wind development. Many of the enhanced ITCs, stemming from ARRA, and since extended, are set to expire at the end of 2011. The disagreeable political climate in Washington will threaten the renewal of these incentives, and could drive uncertainty through the market and delay developments.

Regulatory

Regulatory pathways for siting and permitting offshore wind farms must be stable, and well understood to facilitate a rapidly expanding market. For the past decade, no rational system for applying for wind farm permits, and reviewing and approving or denying those requests existed in the US. The Minerals Management Service (MMS) was created in 1982 to manage oil and gas development on the outer continental shelf. When Cape Wind and other early offshore wind projects began seeking approval, MMS had little capability to manage wind development. Not until the Energy Policy act of 2005 was the MMS specifically given authority over offshore wind development, and the agency was renamed in 2010 as the Bureau of Ocean

Energy Management, Regulation and Enforcement (BOEMRE) to reflect its broader purview. A streamlined permitting process for offshore wind projects was established in 2009, with the process establishment project named "Smart from the Start." The new permitting process is now supposed to take 3 years, as opposed to the travails of Cape Wind which has been in litigation for over a decade, however indications are that the permitting process today takes longer than 3 years. BOEMRE was restructured in October 2011 in response to the Deep Horizon oil spill. BOEMRE, is now responsible for offshore wind farm permitting. With a clear regulatory path through the BOEMRE, offshore wind development in the US can proceed with dramatically reduced friction through the approval process.

Resource Availability

Offshore wind development in the US, and especially on the East Coast, is particularly attractive because the wind resources are large, the resource is close to dense population centers, and much of the wind resource is available in shallow and transitional waters.

Economics and Technology Development

The NREL project database provides information on proposed project cost. This data show that offshore project costs are between 2 to 4 times those of an onshore wind one. For onshore wind systems, the primary cost driver is the price of the turbine, and conversely for offshore wind, the turbine only accounts for approximately 25-30% of the cost of the entire installed system. Offshore wind farm costs are heavily dominated by O&M, logistics, and support infrastructure costs. Consequently, offshore wind development is spurring innovation and technological change for much larger machines (5+ MW), taller towers, machine architecture changes, and new foundation and platform solutions for deeper water installations. These technologies are geared towards capturing more wind per turbine, which helps justify higher per turbine costs offshore, and also towards lowering the operating and maintenance costs.

Financing the development and construction of a wind farm is a critical economic consideration. Offshore wind farms have much higher risk than their onshore counterparts due to the new turbine and foundation technologies without sufficient track records of performance, lack of experience along the entire domestic supply chain, and the higher complexity of operating large construction projects at sea. This will make raising money, often over a $1 billion, quite difficult and will raise the interest rates on loans for projects and expected returns to equity holders. Domestic players across the supply chain can reduce their risk profile by leveraging European experience through partnerships and joint ventures.

Maryland Project Opportunity

Maryland Goals

The Maryland RPS requires 20% renewable energy by 2022, with a 2% Solar Carve-out. The RPS is phased-in beginning in 2006 and grows to 20% by 2022.

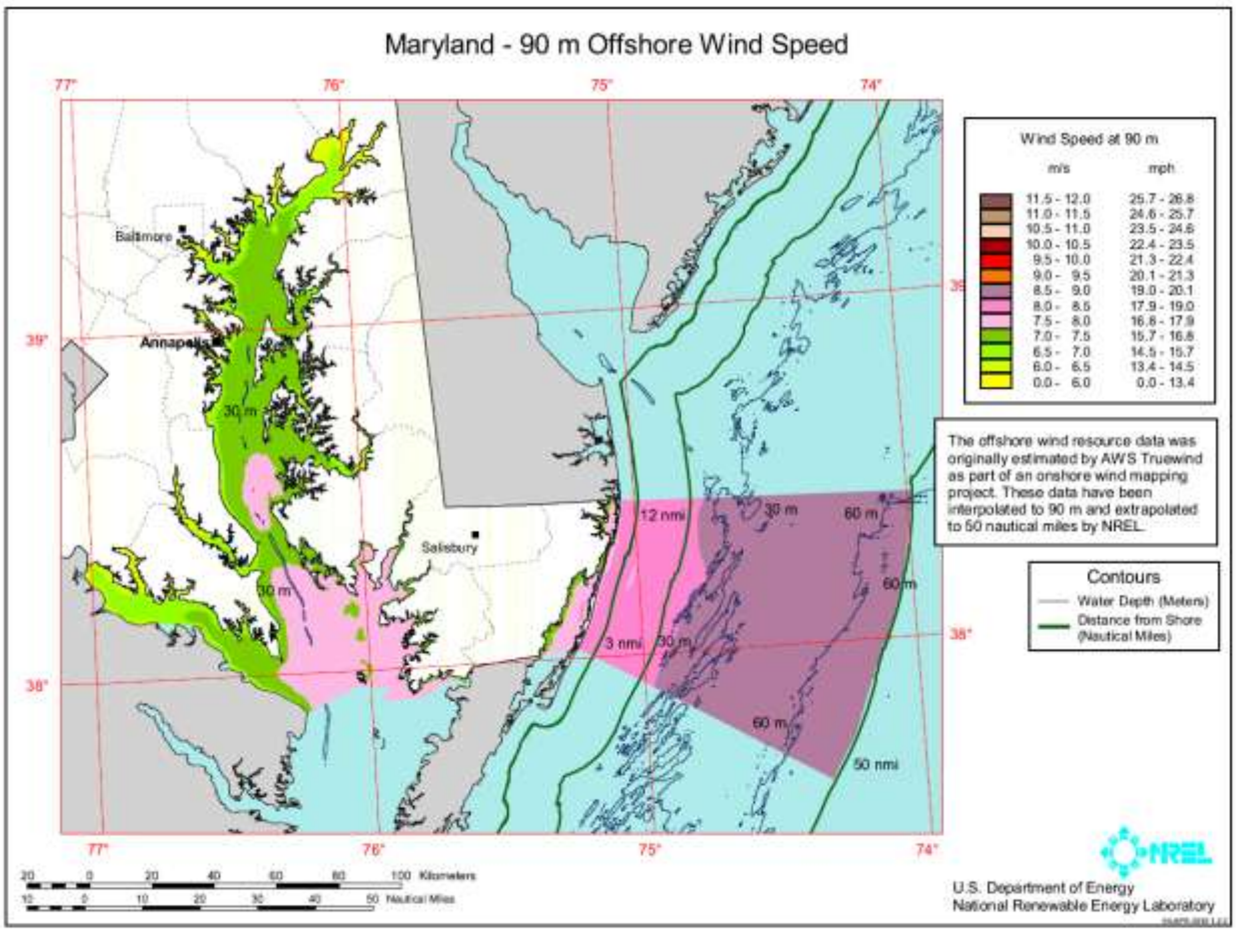
Maryland Resource and Potential

Jeremy Firestone's report, "Maryland's Offshore Wind Power Potential," calculates the estimated potential based on land area available for offshore development and fulfilling the state RPS with differing levels of offshore wind. The chart below, adapted from this report, shows the tremendous resource in Maryland compared to its electrical consumption. At currently feasible depths of 0-35 meters, Maryland could theoretically install 14.6 GW of offshore wind capacity and meet 67% of the state's total electrical needs. The resource in transitional depths from 35-50 meters is very similar, and the resource potential of deep-water wind is very large, both in overall GW and in comparison to the state's electrical consumption.

Depth (meters)	Available Area (km2)	Nameplate Capacity (MW)	Percentage of 2007 Maryland Electric Consumption Served

0-35	2,322	14,625	67%
35-50	2,310	14,550	66%
50+	4,894	30,820	141%
Total	**9,526**	**59,995**	**274%**

Table 1 Source: Firestone et al, "Maryland's Offshore Wind Power Potential"



While the large offshore wind resource in Maryland is vast, the market in the US is still quite nascent, and the Maryland RPS calls for 20% renewable by 2022 with 2% coming from solar energy. When the offshore development potential is considered within the current state RPS, the picture is still quite compelling and this potential should be used to help generate demand.

Fulfilling 25% of Maryland's available RPS in 2022 with offshore wind would require 1 GW of installed capacity, and would supply 4.5% of Maryland's electric demand (25% of 18% = 4.5%). Similarly 50% of the 2022 RPS fulfilled with offshore wind would require almost 2 GW of installed capacity and supply 9% of the state's electricity.

As a comparison, several European countries already have total wind penetration rates over 10%. Denmark – 24%, Portugal – 14.8%, Spain – 14.4%, Ireland – 10.1%[1]. Within Spain, the region of Navarra has 60% of electricity supplied by wind, and the target is to achieve more than 90%. By 2022, the eastern shores of the US are expected to have almost 9 GW of wind installed, so 1 to 2 GW installed in Maryland is reasonable.

Year	RPS less solar carve out	% of RPS Fullfilled by Offshore Wind	Offshore Wind Installed Capacity (MW)
2022	18%	25%	975
2022	18%	50%	1950

Source: Firestone et all, "Maryland's Offshore Wind Power Potential"

[1] EWEA, Wind in Power: 2010 European Statistics, February 2011

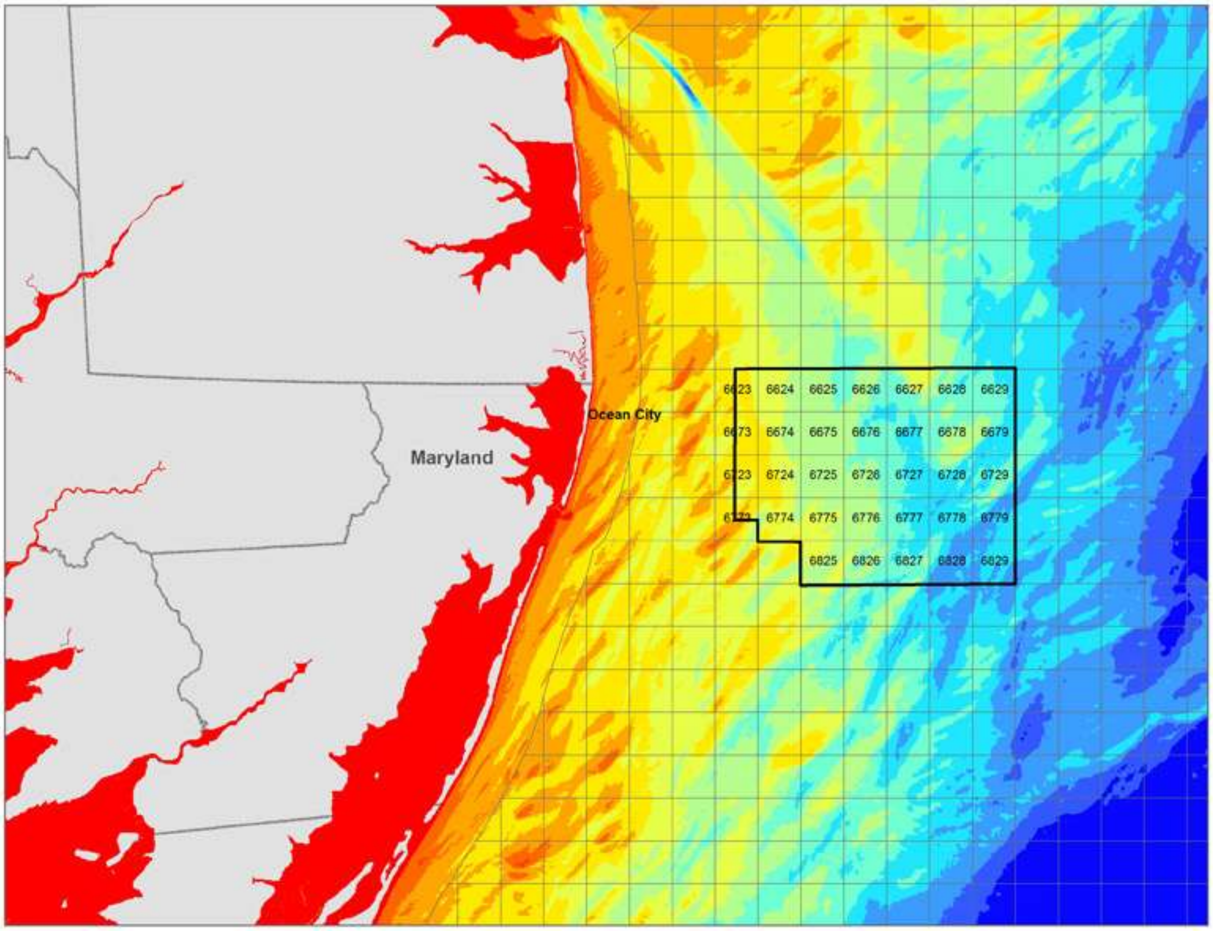


Figure 7: Apex Wind Energy - Area of interest for Offshore Wind Development in Maryland

US Market Outlook

The US market outlook for offshore wind is strong. Already, 1,300 MW of wind development projects are in mid to late stages of development and nearing construction, and our analysis shows that 7,000 MW of projects have been proposed and are in the early stages of planning. Major European companies with extensive wind energy experience are looking to the US as a key growth sector. Some of the turbine manufacturers are taking equity stakes in offshore projects. Siemens has restructured its financial are to be able to provide project finance for large renewable developments. Gamesa has opened an offshore wind research center in Virginia in a joint venture with Northrop Grumman shipbuilding, and is expected to erect a test turbine 2012. The establishment of the accelerated permitting process through BOEMRE's "Smart from the Start" program should allow the full permitting process to be completed within its stated goal of 3 years and lead to more leases being issued in 2012.

Developer	Project	Project Status	Region	State	MW
ScandiaWind	Aegir Project	Proposed	Great Lakes	Michigan	500
Bluewater Wind NRG Energy	NRG Bluewater Wind New Jersey	Limited Lease	Atlantic	New Jersey	348
Bluewater Wind NRG Energy	Mid-Atlantic Park	Cancelled	Atlantic	Delaware	450
Baryonyx Corporation	Mustang Island	Land Lease	Gulf of Mexico	Texas	1000
Baryonyx Corporation	Rio Grande North and South	Land Lease	Gulf of Mexico	Texas	1000
Cape Wind	Cape Wind	Active	Atlantic	Massachusetts	468
Deepwater Wind (Winergy)	Winergy Jones Beach	Proposed	Atlantic	New York	940
Deepwater Wind (Winergy)	Winergy South Long Island	Proposed	Atlantic	New York	300
Deepwater Wind (Winergy)	Block Island	Active	Atlantic	Rhode Island	30
Deepwater Wind (Winergy)	Deepwater Wind Energy Center (DWEC)	Proposed	Atlantic	Rhode Island	1000
Deepwater Wind (Winergy)	Garden State Offshore Energy	Active	Atlantic	New Jersey	350
Delsea Energy	Newport Nearshore Windpark	Proposed	Atlantic	New Jersey	382
Fishermen's Energy	Fisherman's Energy New Jersey	Limited Lease	Atlantic	New Jersey	350
Hull	Hull Offshore Wind	Proposed	Atlantic	Massachusetts	15

Apex	Cape Lookout Energy Preserve	Proposed	Atlantic	North Carolina	450
Apex	Hampton Roads Offshore Wind	Proposed	Atlantic	Virginia	450
Apex	Maryland Offshore Wind	Proposed	Atlantic	Maryland	450
Apex	Lake Erie Offshore Wind Project	Proposed	Great Lakes	New York	500
Principle Power	Tillamook County Offshore Wind	Proposed	West	Oregon	150
Wind Energy Systems Technologies (WEST)	Galveston Offshore Wind	Proposed	Gulf of Mexico	Texas	300

Proposed Offshore Wind Farms Along the Eastern Seaboard:

Product Segmentation

Work Breakdown Structure

The lifecycle cost of an offshore wind project can be broken down in to five large categories: project development and permitting, turbine, balance of plant, logistics and installation, and operation and maintenance. Within each of these large categories are subcategories, each with their own sets of activities necessary.

There have been multiple studies to analyze the lifecycle cost of offshore wind projects. It is very difficult to have high confidence in these reports and we will use them as directional data. While the engineering and manufacturing costs are clear, we are starting to understand the project development and permitting process and the logistics and installation requirements, as the costs are highly variable due to geography location, legislation, and weather conditions.

	Low Range	Kinetik Model	High Range
Project Development and Permitting	1%	*2%*	8%
Wind turbine	22%	*26%*	42%
Balance of plant	20%	*27%*	30%
Logistics and Installation	10%	*20%*	22%
Operation and Maintenance	14%	*25%*	30%
TOTAL	67%	**100%**	132%

Table 2 Lifecycle cost of offshore wind farms. Multiple study ranges.

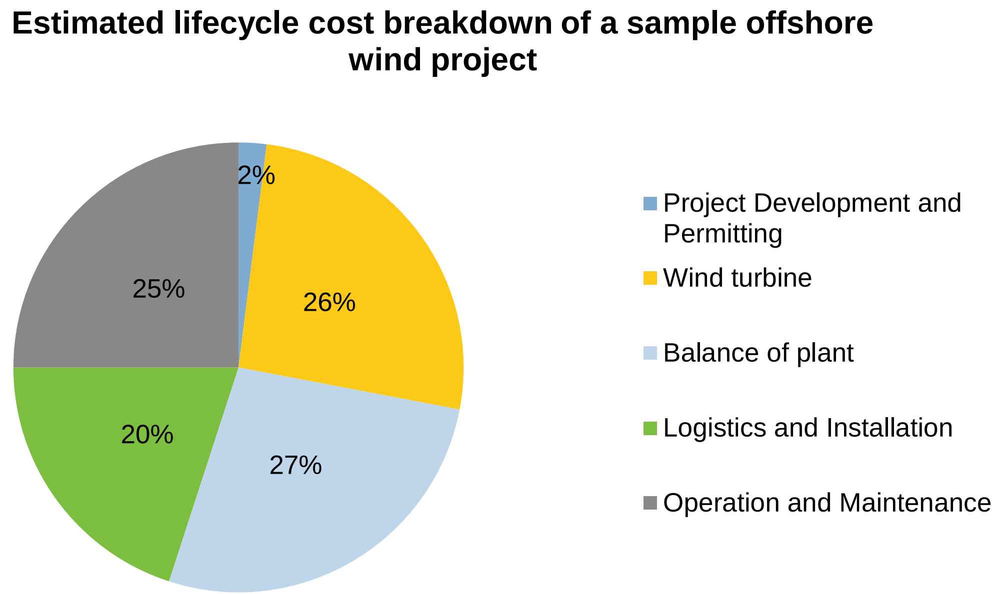


Figure 8 Estimated lifecycle cost breakdown of a sample offshore wind project

The National Renewable Energy Lab (NREL) has been developing a cost database for the wind industry. They recently published a graph indicating the capital cost per kilowatt. This graph, shown below, clearly shows the variability of installed cost per kilowatt, especially as near shore installations start becoming more difficult to site and industry is required to go into more geographically and technically challenging locations. The forecasted cost per megawatt installed is currently $4.3 Million.

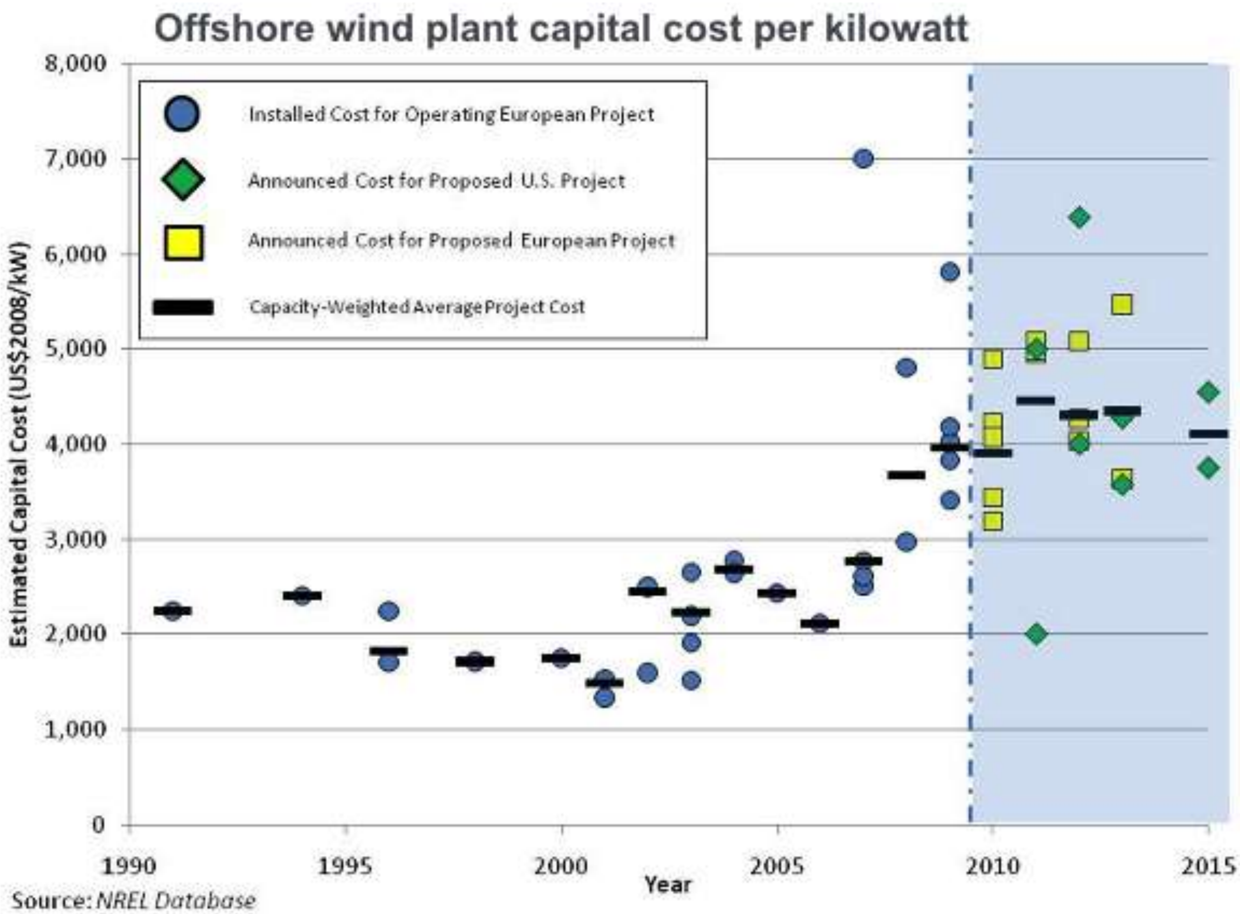


Image 1 Offshore wind farm installed cost

With the overall project cost structure modeled, we further analyzed the make up of installed cost as it pertains to labor, steel and non-metallic components. Steel and ferrous components make up a significant proportion of the installed offshore wind turbine value. Approximately 44% of installed costs are embedded in steel components and steel-related activities. Within each of these large categories are subcategories, each with their own sets of necessary activities. A list of each activity and a description is provided later in this section, along with the typical proportion of installation cost the activity comprises, with special focus on the proportion of steel cost. The chart below shows the proportion of by input type.

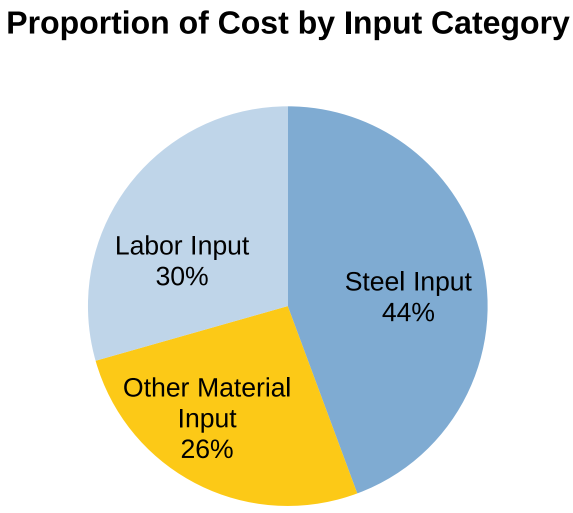


Figure 9 Percent Installed cost breakdown between materials and labor

Steel costs are most highly concentrated in the wind turbine and balance of plant categories. Overall, steel makes up almost ¾ of the total wind turbine weight; when considering the amount of steel necessary for foundations, this number should increase significantly.

On an activity-based level, the table below illustrates the amount of steel cost as a proportion of total installation costs.

Category	Component	Sub-Component	Steel Proportion of Installation Costs
Project Development	Met station surveys	Met station structure	0.20%
Wind Turbine	Nacelle	Nacelle bedplate	1%
Wind Turbine	Nacelle	Main bearing	1%
Wind Turbine	Nacelle	Main shaft	1%
Wind Turbine	Nacelle	Gearbox	10%
Wind Turbine	Nacelle	Generator	2%
Wind Turbine	Nacelle	Yaw bearing	0%
Wind Turbine	Nacelle	Nacelle cover	1%
Wind Turbine	Nacelle	Fasteners	0%
Wind Turbine	Rotor	Hub casting	1%
Wind Turbine	Rotor	Blade bearings	0%

Wind Turbine	Rotor	Fabricated steel components	0%
Wind Turbine	Tower	Formed, welded, delivered Steel plate	4%
Wind Turbine	Tower	Personnel access and survival equipment	1%
Balance of Plant	Turbine Foundation	Turbine foundation	15%
Balance of Plant	Turbine Foundation	Transition Piece	5%
Balance of Plant	Offshore Substation	Structure	1%
		Total	44%

Economic Value

The steel product value for offshore wind turbines on the US Atlantic Coast will be quite significant as the industry develops. Figure 10 shows the yearly and cumulative steel value expected through 2025. Even in a small, developing market, $1 billion worth of steel products will be purchased for installation in wind farms throughout the Atlantic region, from New England down through Georgia. As the US offshore wind industry matures and grows, we project steel product content of nearly $3 billion in 2020, and above $10 billion in 2025.

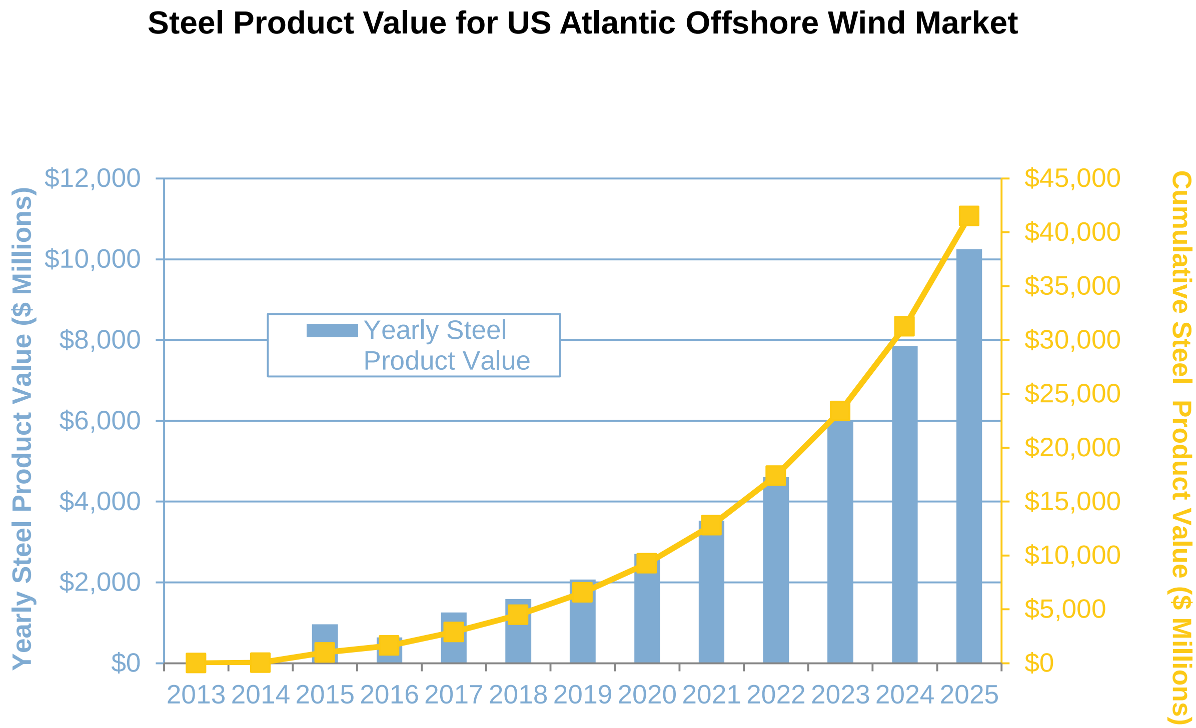


Figure 10 Eastern Seaboard annual and cumulative market value for steel products.

Work Breakdown Structure Activities

We have developed a work breakdown structure for a sample wind farm. The information below is based on a sample European offshore installation information. A list of each activity and a description is detailed below, along with the typical proportion of installation cost the activity comprises, with special focus on the proportion of steel cost per 3.6 MW offshore turbine installed. This study takes the full installed costs for a 500 MW offshore wind farm and then amortizes the costs on a per-installed-turbine basis. Changes in technology and materials input market dynamics effect on the overall value assigned to any given activity have been taken into account by decreases on installed cost per megawatt.

1. Project Development and Permitting

1.1. Met station survey and structure

Met stations are erected at a proposed wind farm site to monitor and analyze all aspects of meteorological and oceanographic conditions at the site. They are typically made of galvanized steel lattice. Typically, on a per-turbine basis, the proportional cost of the met station is 0.2%.

2. Wind Turbine

Offshore turbines range from 2 to 5 MW, but a typical Siemens 3.6 MW can weigh up to 400 mt. Its major components are the nacelle, rotor, and tower. Generally, this is an area of the offshore wind turbine value chain is highly steel-intensive. Suppliers and operations geared towards offshore turbines are located in Europe, and have yet to establish US operations. Overall the turbine makes up approximately 39% of installed costs, with its steel composition comprising 21% of installed costs.

2.1. Nacelle

The nacelle houses the generator, gearbox, and monitoring, communications, control and environmental maintenance equipment. It is principally composed of a bedplate and cover. Nacelles are large units and typically the heaviest and highest lift. The nacelle sits atop the tower and supports the rotor, converting the rotational energy. It takes 10-20 man-days to assemble a large nacelle. Establishing local assembly of nacelles in a given market opens up possibilities for significant local supply. The steel component of the nacelle typically runs 12% of the installed turbine value. The nacelle is comprised of:

2.1.1. Bedplate

The bedplate supports the drive train and the rest of the nacelle components and transfers loads from the rotor to the tower. Bedplates are either cast SG iron or steel fabrications and thus are subject to market pricing. However, they typically comprise 1% of installed turbine value.

2.1.2. Main Bearing

The main bearing supports the rotor. Typical components are: forged rolled rings, rolling elements, rolling element support, lubricants and seals, SG iron bearing housing. A pair of main shaft bearings and housings may have mass up to the order of 25 mt. They typically cost 1% of installed costs.

2.1.3. Main Shaft

A high grade steel forged shaft that can weigh up to 30mt. They typically cost 1% of installed costs.

2.1.4. Gearbox

The gearbox is over 96% steel and can cost typically 10% of installed value. However, gearbox technologies are rapidly shifting and costs or capabilities may suddenly change.

2.1.5. Generator

The generator is not a steel intensive component. It typically makes up 2% of installed costs.

2.1.6. Power-takeoff

This component is comprised of the power converter, transformer, switchgear and cables. It is not steel intensive and makes up 4% of installed costs.

2.1.7. Control System

The control system is comprised of sensors, hardware, software, and control panels. It interfaces with the SCADA system and typically makes up 1% of installed costs. It is not steel intensive.

2.1.8. Yaw System

The yaw system orients the nacelle during operation. It is not steel intensive and makes up 1% of installed costs.

2.1.9. Yaw Bearing

This component connects to nacelle and the tower, and consists of steel balls and forged rings which can make up to 0.5% of installed costs.

2.1.10. Auxiliary systems

These are systems such as brakes, cooling, air conditioning, fire protection. They are not steel intensive and make up less than 1% of installed costs.

2.1.11. Nacelle cover

This can be made of steel or fiberglass and can weigh up to 20 mt. It can make up to 1% of installed costs.

2.1.12. Engineered components

Generally low cost, off the shelf components such as flooring, lighting and small fasteners which are not steel intensive and make up less than 1% of installed costs.

2.1.13. Fasteners

Typically are small steel components which make up to 0.1% of installed costs.

2.1.14. Condition monitoring system

Sensors and systems which make up to 0.2% of installed costs.

2.2. Rotor

The rotor extracts kinetic energy from the wind and converts this into rotational energy in the drive train. It is comprised of blades fastened to a hub and then to a turbine drive. The hub, blade bearings and engineering components are steel-intensive. Altogether the rotor makes up to 8.8% of installed costs, with steel comprising 1.6%:

2.2.1. Blades

Blades are typically made of composite materials, the blade root, lightning protection, and lights. Their function is to capture wind energy and transfer torque to the drive train. They make up less than 6% of installed costs.

2.2.2. Hub Casting

This all-steel component makes up to 1% of the installed cost. It is generally 30-40 mt and can be made of cast iron or high strength and grade steel.

2.2.3. Blade Bearings

Up to 5 mt of high grade steel bearings can cost up to 0.5% of installed costs.

2.2.4. Pitch System

Either a hydraulic or electric actuation system to control the pitch of the blades. This is not steel intensive, and makes up to 1.5% of installed costs.

2.2.5. Spinner and auxiliary systems

Make up less than 1% of installed costs and are not steel intensive. The spinner is a protective cover for the hub.

2.2.6. Fabricated steel components

A range of products such as flame-cut steel circles, which can be supplied by many fabricators. These typically cost 0.2% of installed costs.

2.2.7. Fasteners

Described above under "nacelle".

2.3. Tower

The tower is a tubular steel structure that provides support to the turbine assembly and the balance of plant components. The primary cost of the tower is steel, making up 5.5% of installed costs, with a remaining 1% comprised of add-ons and equipment

2.3.1. Steel

The tower is made of steel plate cut, rolled, and welded together into large sections. In installation, tower sections are bolted to each other during assembly, or are pre-assembled at port. Tower height is determined by the diameter of the rotor and the clearance above the water level, typically 60 to 80m and between 200-400 mt (90% of the mass is steel). Tower diameter and strength depend on the weight of the nacelle and expected wind loads. Steel price can fluctuate between $900/mt - $1500/mt depending on market conditions. Typical European grades for offshore turbines are grade S355 EN10.113-2 NL steel, the closest US equivalent is ASTM A656 gr.50. The steel in the tower should make up to 4.5% of total installed cost.

2.3.2. Personnel access

These are ladders or elevators installed inside the tower for access. They are typically made with steel and make up to 1% of installed costs.

2.3.3. Electrical System

Typically a control panel at the base of the tower. These are not steel-intensive and make up to 0.5% of installed costs.

2.3.4. Tower lighting

Lighting must be provided for safe movement in the tower. These are not steel intensive and make up to 0.2% of installed costs.

2.3.5. Fasteners

Typically are small steel components which make up to 0.1% of installed costs.

3. Balance of Plant

Balance of plant includes all the components of the wind farm, which are outside of the turbine. These costs typically comprise 30-33% of installed costs. On a per turbine basis the single largest expense will be the foundation. However, this depends on the type of foundation structure that is chosen and at what depth. A discussion of foundation type can be found in the technology section. For purposes of this analysis, the high range of foundation costs will make up 20% of installation costs, with steel being a large component of that cost. Balance of plant is comprised of cables, turbine foundation, offshore substation and onshore substation.

3.1. Cables

Altogether cables will make upward of 5% of installed costs. These include export cables, arrays, and protection. These cables are not steel-intensive components.

3.2. Turbine Foundation

The turbine foundation can vary depending on the type of foundation structure chosen (e.g., monopole vs. TPS). However, regardless of the type of structure, common components of the foundation will include a transition piece, connecting the foundation and the tower, crew access, j-tube, scour protection, and a sacrificial anode. Scour protection is usually made from rock, but the remaining components are all steel-intensive and comprise up to 20% of installed costs (the transition piece alone can make up to 5% of installed costs). However, these costs are highly dependent on the foundation structure chosen.

3.3. Offshore Substation

The offshore substation is comprised of the electrical system, facilities, and structure. Assuming one offshore substation for the wind farm, the costs should typically make up to 3.5% of installed costs. Steel is most present in the substation structure (although they can be made from aluminum). The potential steel value in an offshore substation can be up to 1% of installed costs.

3.4. Onshore substation

Similar to the offshore substation but not requiring the structure component, these tend to cost 2.5% of installed costs and the necessary steel component is minimal.

4. Logistics and Installation

Logistics and installation will comprise above 20% of installation costs. These are labor and transport costs and thus do not have embedded steel components. Transport costs are highly dependent on daily charter rates. The need to develop the transportation infrastructure could create secondary levels of demand depending on the decision to pursue a ship and barge manufacturing industry. A discussion of vessel needs is located in the appendix.

Image 2 Offshore Transformer Station - Transport at sea. Source

5. Operation and Maintenance

Much like logistics and installation, this category is labor intensive, with some level of steel intensity due to capital replacements. However, those amortized steel costs are negligible. Overall, this category represents 25% of installed costs. The main activities in this category are:

5.1. Component maintenance and overhaul

There will be requirements for the use of consumables as well as repair and overhauling of components, such as generators and gearboxes. Some of this work is usually outsourced to capable local companies. However it is difficult to quantify the economic value of this activity to the region.

Further considerations

While there is a large proportion of steel embedded in the offshore wind turbine value chain, there are secondary and tertiary effects, which would warrant further investigation. First, as per the discussion on US sourced vessels; shipbuilding is a steel-intensive activity, and the production of ship-building plate would be a necessary and compatible consideration in the development of Maryland's steel capabilities.

Vessels necessary for the installation of offshore wind turbines in generally fall into 4 activity categories:

Activity Type	Vessel needs
Turbine import/Delivery	Large open-hatch cargo vessel
Foundation delivery and installation	Jack-up crane vessel or floating derrick barge
Wind Turbine Installation	Leg-stabilized jack-up crane ships, jack-up crane barges, jack-up crane ships
Maintenance	Crew boats

Orders for vessels average 6 to 12 months lead time to enter a construction cycle at large shipyards. Several smaller yards in the Northeast and Gulf may be able to accommodate immediate orders for smaller vessels, but lack the ability to handle multiple vessel capacity. Kinetik estimates demand for approximately 25 newly built, specialized vessels to support the industry based on current project announcements.

Supply chain analysis

Vestas and Siemens are the dominant offshore wind turbine suppliers in Europe. However, several manufacturers have announced supply relationships for planned offshore farms, with the general trend in this new generation of technology towards machines over 5 MW coupled with direct drive and integrated architectures.

The table below lists current offshore platforms in the market and announcements of new models (due to warranty and other supply chain issues, Asian OEMs have not been included on the list).

Manufacturer	Model	Type	Capacity (MW)	Rotor Diameter (M)	Nacelle Weight (MT)	Deployment	No. Turbines Online
Alstom		Direct Drive	6	150		Announced	0
Areva	M5000	Shaped Planetary Gear	5	116	233	Operational	6
Bard	5.0	3-stage Planetary Spur Gear	5	122	270	Operational	26
	4.5	3-stage Planetary Spur Gear	4.5	122	275	Announced	0
Gamesa	G10X	2-stage integrated	4.5	138		Announced	3
			7			Announced	0
Nordex	N150		6	150		Announced	0
RePower	5M	3-stage Planetary Spur Gear	5	126	315	Operational	44
	6M	3-stage Planetary Spur Gear	6.25	126	325	Announced	0
Siemens	2.3-93	3-stage Planetary Spur Gear	2.3	93	82	Operational	250
	3.6-107/120	3-stage Planetary Spur Gear	3.6	107/120	105	Operational	134
	6.0-120	Direct Drive	6	120	350	Announced	0

Vestas	V80	Planetary/Spur Wheel gearbox	2	80	67	Operational	200
	V90	Planetary/Spur Wheel gearbox	3	90	70	Operational	373
	V164	Planetary/Spur Wheel gearbox	7	164	350	Announced	0
						Total Operational	**1033**

As per the technology roadmap, available turbines and announced models, the apparent trend will be to build offshore wind farms using larger capacity turbines. This lowers the installation and infrastructure cost optimizing the overall cost of installation. While the current market is led by the installation of medium size machines such as, Siemens 3.6 MW or Vestas' 3 MW, these will be replaced by machines in the 5 MW range. While we believe Siemens will be the market share leader for the foreseeable future, especially with the introduction of the 6 MW machine, the new entrants will affect Vestas market share. New players such as Alstom and Areva, both very strong companies with strong foothold in the power generation industries, should capture significant market share. Fast followers will likely be Gamesa, RePower and GE, who all possess technology but remain unclear regarding offshore plans.

To develop a healthy offshore wind industry, it is necessary to have a stable and efficient supply chain. The offshore wind supply chain predominantly resides in Europe and Asia, which is co-located with the areas of greatest offshore demand. The overall structure of the supply chain is highly dependent on apparent and future demand, WTG supplier preference and capability, and embedded regional infrastructure. Up until 2008 there was a bottleneck for key components (large bearings, blade pitch bearings, castings and forgings), but the financial crisis eased up on much of the demand and had the effect of freeing up supply.

There is large variability between wind turbine manufacturers in their level of vertical integration with OEMS. Siemens and Vestas are highly integrated with their suppliers while Alstom and Gamesa outsource no core technology. Similarly, tier one and tier two suppliers vary in their level of integration.

Current State – Major Component Suppliers in Europe and Asia

The main supply components in the offshore wind turbine supply chain are: blades, gearboxes, generators, bearings, power converters, power transformers, towers, castings, forgings, foundations, labor, vessels, substations, cables, hammers, ports.

Blades

The major offshore WTG suppliers: Siemens, Vestas, Gamesa, Areva, Repower, all have in-house blade manufacturing capability. These operations are located in Europe. However, novel blade technology by Blade Dynamics is being developed in the US South. Independent offshore blade manufacturers in Europe include: LM Windpower, SGL Rotec, Sinoi. Several other manufacturers reside in China.

Gearboxes

Most offshore wind gearbox suppliers are from Germany. The major suppliers are: Winergy, Hansen Transmissions (Belgium), Bosch Rexroth, Moventas (Finland), RENK AG, Jahnel-Kestermann Getriebewerke GmbH, Eickhoff, Wikov (Czech Republic), Brevini (Italy), Dalian Heavy Industry (China), David Brown (UK). Winergy, Bosch Rexroth and Hansen are the most commonly used by the large offshore WTG manufacturers.

Generators

Vestas has in-house supply capability. However, most permanent magnet offshore generators have been supplied by ABB (Finland), The Switch (Finland), and Coverteam (France). Dalian Tinyuan Motor has double-fed induction generators operating offshore of China, as well.

Bearings

Independent manufacturers SKF (Sweden) and FAG (Germany) are the most established suppliers of small to large bearings for offshore wind.

Power Converters

Vestas and Siemens both have in-house manufacturing capacity for power converters. The manufacturers with offshore supply experience are ABB (Switzerland), Winergy (Germany), Converteam (France) and Woodward (Germany).

Power Transformers

Similar to power converters, Siemens can supply its own transformers. The largest suppliers are ABB, SGB (Germany), Schneider Electric (France), and CG (Belgium).

Towers

Vestas can supply its own offshore towers, which require special anti-corrosive properties to maintain low costs, although they are outsourcing manufacturing. Most experienced suppliers are near demand in Denmark and Germany. Ambau, SIAG, Hnedricks, Bladt Industries and Skykon are large European suppliers with offshore experience. There are some suppliers located in China.

Castings

Castings for the frame of the nacelle and the hub are made of steel. Suppliers that serve the major WTG manufacturers are mostly located in Europe, predominantly in Germany: Eisengiesserei Torgelau, Silbitz, Heavycat Karlstadt (Sweden), and Sakana (Spain).

Forged components

Steel and iron forged components make up many of the smaller wind components and main shafts. The supply here is evenly distributed between Europe and Asia, both serving major WTG manufacturers. Pilsen Steel (Czech Rep.), Celsa Group (Poland), Forciature Mame (Italy), Taewoong (S. Korea), PSM (S. Korea).

Balance of Plant

In Europe, balance of plant requirements have spurred cluster development to serve foundation, transformer platform, cable, substation and installation needs.

Foundations

Currently steel monopile is the dominantly-used foundation technology (80% market share) in operating offshore wind farms. However, as new machines grow, tripods are required. Other technologies depend on depth of deployment (discussed in detail in below in Technology Roadmaps: New Foundation Concepts): gravity-based, TLP, floating mono-structures.

Suppliers of steel structures are mostly located in Europe. Only one supplier of monopiles, transition pieces, and transformer platforms is located in the US: Mass Tank Sales Corp.

Many companies offer monopiles: AMBAU, Bladt Industries, COOEC, CS Wind Corp, Dajin Heavy Industry, EEW-SPC GmbH, Hendricks Industries, Korindo Wind, Mass Tank Sales, Per Aarself, Sif Group, SIAG, Skykon, Smulders, Tata Steel UK, Tees Alliance Group, Weserwind GmbH, ZPMC.

A fewer number offer tripod technology: Aker Solutions, COOEC, Dajin Heavy Industry, EEW-SPC GmbH, Sif Group, SIAG, Tees Alliance.

Floating structures: Statoil has demonstrated floating technology, with one Siemens turbine in the North Sea in Norway. EDP and Principle Power are testing a floating platform in Portugal. The MIT Tension Leg Platform (TLP) it showing extremely good results in the lab. These technologies will be further developed with in the next 3-5 years. We expect some full size demonstrations in the 2015-2017 timeframe.

Transition pieces

Transition pieces are steel intensive and require high anti-corrosion capability. Major suppliers are: AMBAU, Bladt Industries, EEW-SPC GmbH, Mass Tank Sales Corp, Per Aarself, Sif Group, SIAG, Skykon, Smulders, Tees Alliance Group, ZPMC.

Contractors

Many offshore oil and gas firms have converted their skills to service the offshore wind market. While there are specific firms that are performing this service in Europe, there should be ample convertible skill available in the US.

Offshore Substations

Independent suppliers exist located in Europe that have completed substation work: Siemens, Alstom, Schneider Electric, ABB, CG Systems, EDF and SEAS Transmission.

Cables and cable installation contractors

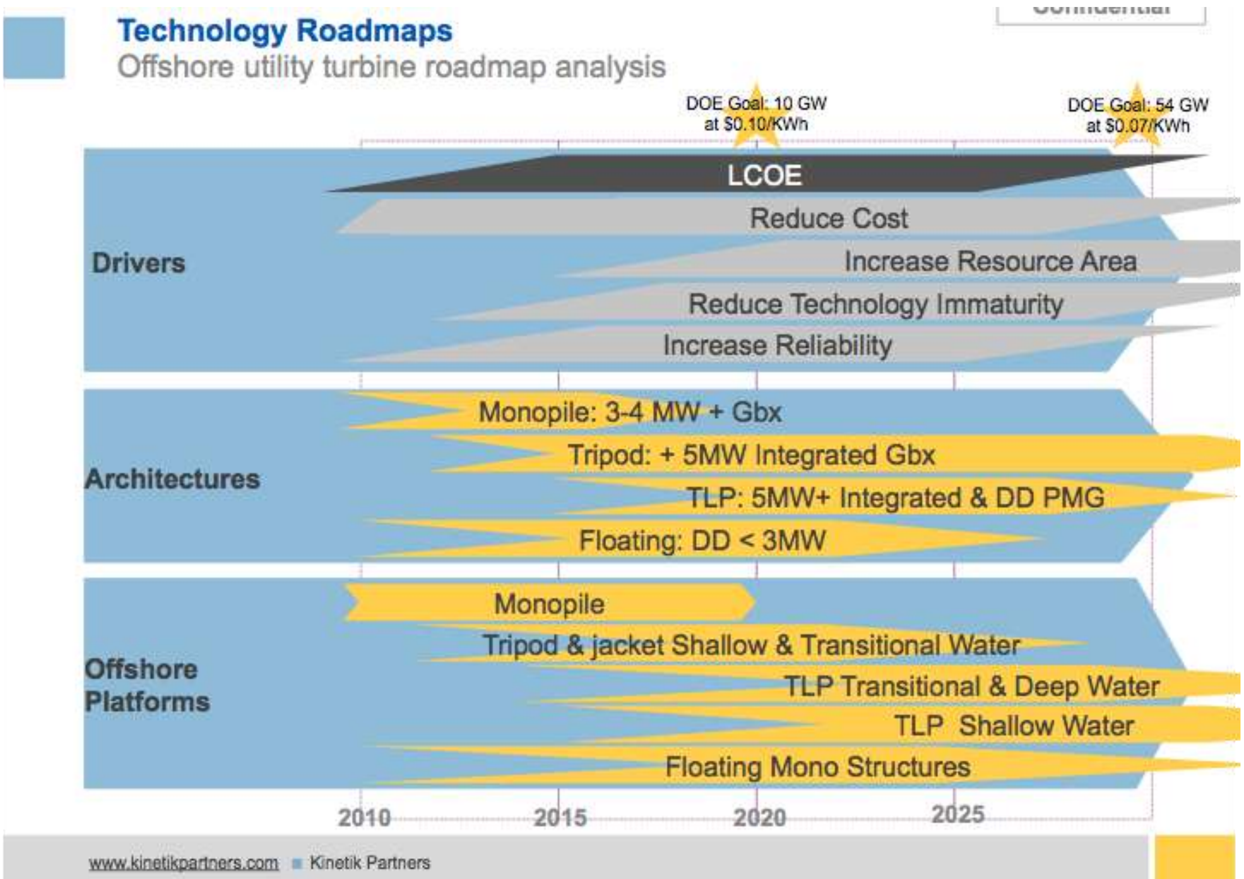
Mostly European in origin, the major suppliers of cable are: ABB, Prysmien, Nexans, Draka, General Cable, NKT, AEI Cables. The US has current cable installation capability.

Hammers

If using monopiles, then the two leading suppliers of hammers in Europe are Menck and IHC Hydrohammer.

Technology Roadmaps

Our technology roadmaps allow us to analyze future product architectures, and the effects they will have in the current supply chain. We look at the enabling technologies, process and material that can provide competitive advantages to regions and to industrial concerns and its interactions with the technology drivers.



The Maryland steel production and fabrication industry could benefit from some of the most dramatic changes the industry will be facing in the future (3-10 years). We believe that there are four technological changes that Maryland could benefit from: (1) the deployment of very large machines, (2) changes of machine architecture, and technologies in demonstration and development, (3) new foundation concepts, and (4) new assembly methodology.

Drivers

The NREL report "*Large-Scale Offshore Wind Power in the United States: Assessment of opportunities and barriers*" identifies four critical barriers inhibiting the deployment of offshore wind to its full potential: (1) High Costs, (2) Technology Immaturity, (3) Limited Resource area, and (4) High Risk and Uncertainty. The following sections explain these barriers and our approach to overcome them.

High Cost: Current offshore system costs are between 2 to 4 times the costs of an onshore wind system. For onshore wind systems, the primary cost driver is the price of the turbine, conversely for offshore wind, the turbine only accounts for approximately 25-30% of the cost of the entire installed system. Offshore wind farm costs are heavily dominated by O&M, logistics and support infrastructure costs. The current technology requires the development of customized vessels for the installation and to support offshore wind plant logistics.

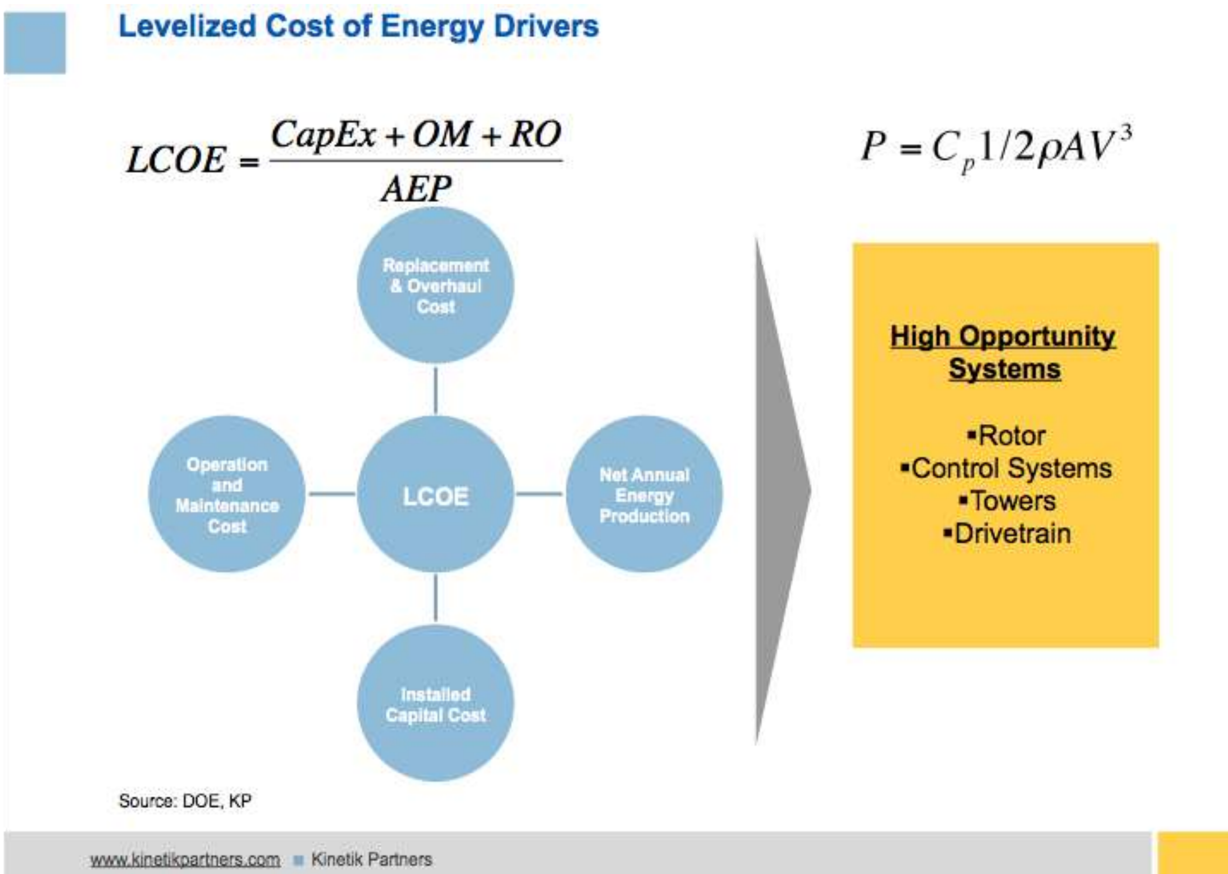
Technology Immaturity: Current technology is still maturing for the requirement of offshore systems. Most turbines deployed today are onshore products that have been marinized. Furthermore, most of the turbines are installed in shallow water with monopile foundations. A large number of dedicated offshore systems on floating platforms are being designed, but as yet not fully deployed in the market.

Limited resource: With the exception of a few demonstration projects, the majority of offshore projects have been deployed in shallow water. This lack of experience and technology limits the areas where offshore platforms can be deployed. In the US, the addition of transitional and deep-water offshore capacity increases the potential capacity by a factor of six, from 450 GW of shallow water capacity to 2,900 GW of total US offshore capacity.

High Risk and Uncertainty: Current offshore wind projects carry a premium cost penalty due to the uncertainty and high risk of the projects and technology. Life-cycle costs of offshore turbines/projects are not clearly understood, and therefore present technical and financial risks during construction, installation, operation and decommissioning.

These drivers are the main cause of the higher Levelized Cost of Energy (LCOE) as compared to onshore wind. As the energy cost from wind decreases, it becomes more attractive as a supply source. Considering the basic equations below for LCOE, to decrease the LCOE, the costs must be lowered, or the annual energy production must go up. In fact, since these are heavily related, it is advantageous to increase the energy production by more than the costs.

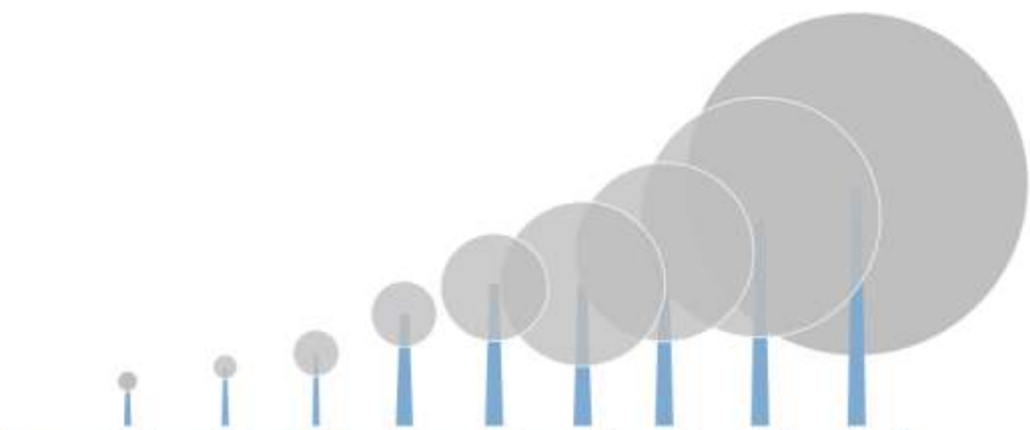
The first technological change, Large Machines, seeks to increase the average energy production by accessing faster wind by going offshore and going higher in the air, and also by catching more wind per turbine by increasing the blade length. The second technological change, machine architecture, is both a response to the larger machines, and a drive to reduce installed and operational costs. The third and fourth changes, new foundations and new assembly methods, are driven by the larger machines, the new architectures, and the push towards deeper water installations.



Larger Machines

There is a trend towards the development to larger machines, as shown in Figure 11. Rotor Diameters are expected to reach 175 meters in the near term, and stretch to 250 meters in 2020.

This drive is to maximize the energy capture per turbine. Looking at the wind power equation $P = C_p*1/2*\rho*A*V^3$, shows that for a given increase in wind velocity, the power output grows by a power of three. (P = Power; C_p= Coefficient of Performance, ie what percent of the theoretical maximum energy the wind turbine produces; ρ=air density; A=swept are of blades; V=wind velocity). An increase in hub height from 80m to 150 m gives access to an increase in wind speeds by 5%. The 5% wind speed increase yields a 15% improvement in power output per turbine, and this opportunity for higher speed wind is driving the turbines to higher heights.



year	1980	1985	1990	1995	2000	2005	2010	2015	2020
kW	35	80	250	600	1,500	5,000	7,500	15,000	20,000
Rotor Diameter	15	20	30	46	70	115	135	175	252
Hub Height	30	40	50	78	100	100	125	150	175

Figure 11 Wind turbine output growth forecast

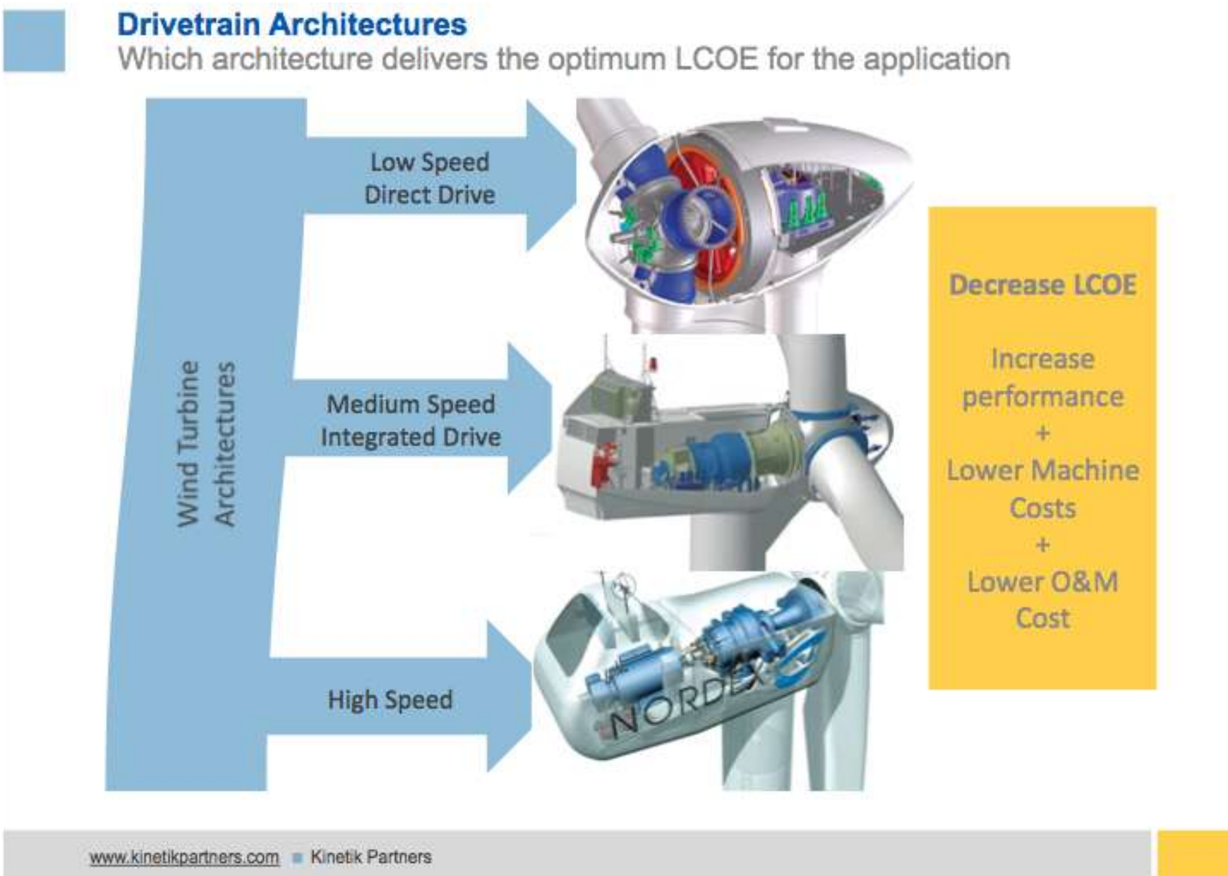
Similarly, the Area, A, grows by the square of the rotor diameter, and so does the power output. In order to double the output of the turbine, the diameter must be increased by 40%. Doubling the diameter increases the power output by a factor of four. The square factor for the area is the primary driver for the increase in machine size and output, since large gains can be achieved by increasing the blade length.

As rotor diameter grows, the power capture of the machine grows, and the remaining systems must grow as well. The generator must increase in capacity, and therefore becomes bigger and heavier. The substructures like the hub and bedplate must be stronger, therefore become bigger and heavier. All the while, economies of scale allow that the power output grows more than the increase in capital cost.

As an example of the development of very large machines, UpWind, a European consortium formed by leading wind turbine manufacturers, service providers and research institutions and funded by the "European Framework Programme 6 " (FP6) have been working on the feasibility of very large systems upwards of 20 MW. They plan to have such a turbine concept in a prototype stage by 2020. While, such a system has proved technically feasible, the supply chain would need to be upgraded with heavy investments to manufacture such large components.

New Turbine Architectures

The three primary wind machine architectures are shown below. Until recently, all wind turbines have been high-speed machines. The difficulties from using a 3-speed gearbox, with its reliability limitations and high cost, are driving the move towards direct-drive machines with no gearbox, and also to an intermediate solution, a medium speed machine incorporating a simpler gearbox.



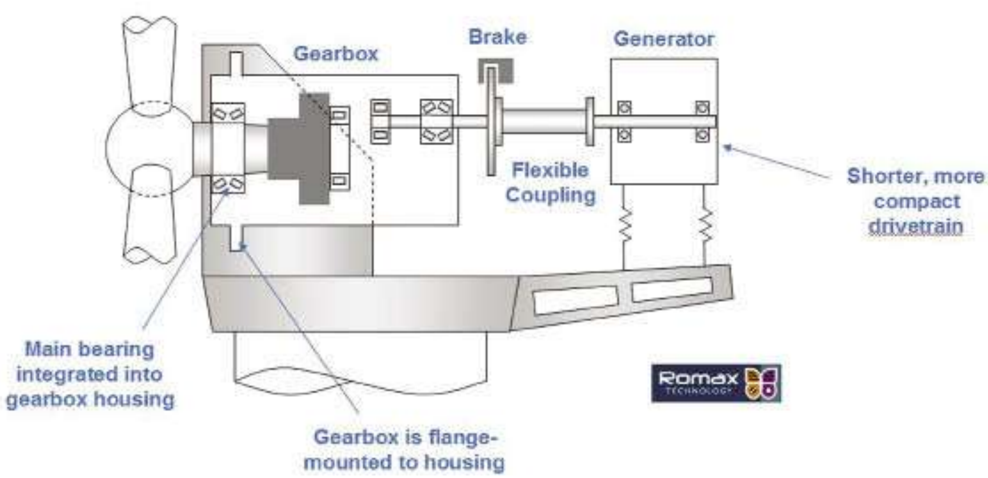
High Speed with 3 Stage Gearbox

This turbine architecture accounts for the majority of the world installations. Current wind machines are high-speed type machines, meaning that the relatively low blade speed (15-20 RPM) is stepped up to the generator rotational speed (1800 RPM) through a 3-stage gearbox. Wind turbines gearboxes endure a variety of high and variable loads stemming from variations in wind speeds such as gusts and lulls, differences in wind speed at the top and bottom of the rotor diameter, and wind turbulence. These variations push high stress loads and vibrations through the drivetrain and are controlled primarily in the main shaft bearings and gearbox. With multiple moving parts and these high and variable loads, the gearbox suffers the most failures of all wind turbine components. In addition, the gearbox is a high cost, complex system. Consequently, we have dual technology paths, (1) to remove non-functional items, and integrating components (Integrated Architecture), or (2) to eliminate the gearbox altogether creating a Direct Drive machine.

Figure 12 Wind Turbine high-speed architecture , Bosch Rexroth

Medium Speed Integrated Drivetrain

The medium speed integrated drivetrain, is a hybrid between the high-speed generator with three-speed gearbox, and the direct drive low speed gearbox-less drivetrains. This architecture integrates components, removing non-functional items



thus reducing part count, and additionally removes the third, or second and third stage of the gearbox making the drive train extremely compact and lightweight.

The French company Areva is deploying a 5 MW machine with a single stage gearbox and 150 rpm permanent magnet generator. With a head mass of 300 tons, this is the lightest machine rated around 5 MW. Gamesa is also deploying an integrated medium speed drivetrain with permanent magnet generator in a 5 MW machine. These architectures simplify the gearbox providing weight reduction benefits of integrating with the nacelle structure, and reduces the need for rare earth permanent magnets compared to direct drive machines.

Image 3 Gamesa G11X and Areva M5000

With this change in architecture there is an opportunity for new suppliers to provide components. As seen below, the Areva Multibrid 5 MW construction consists of the majority of the structure in one very large casting. There is a fabricated bedplate for mounting ancillary equipment, not a large cast bedplate as in typical turbine construction today.

Low Speed Direct Drive

Direct drive machines were the original answer to the gearbox reliability issues. Since direct drive generators operate at rotational speeds around 100 times lower than high-speed generators (15-20 rpm vs 1,800 rpm), the direct drive machine has a much different architecture and material set.

First, the generator diameter is increased. A 3 MW direct drive generator has a diameter over 4 meters, and for larger machines of 6 MW the diameter will reach up to 10 - 12 meters. A conventional high speed 3 MW generator diameter is on the order of 1.2 meters. The increased diameter of a direct drive machine is due to the relationship between the generator output power and how fast the generator moves the magnetic field. Increasing the diameter increases the speed of the magnetic field and helps to increase the output power. A large diameter is also needed to accommodate the many magnet poles that are required by the low rpm. Permanent magnet generator direct drive machines are Direct Current (DC) systems and require more complicated and expensive power electronics (full converters).

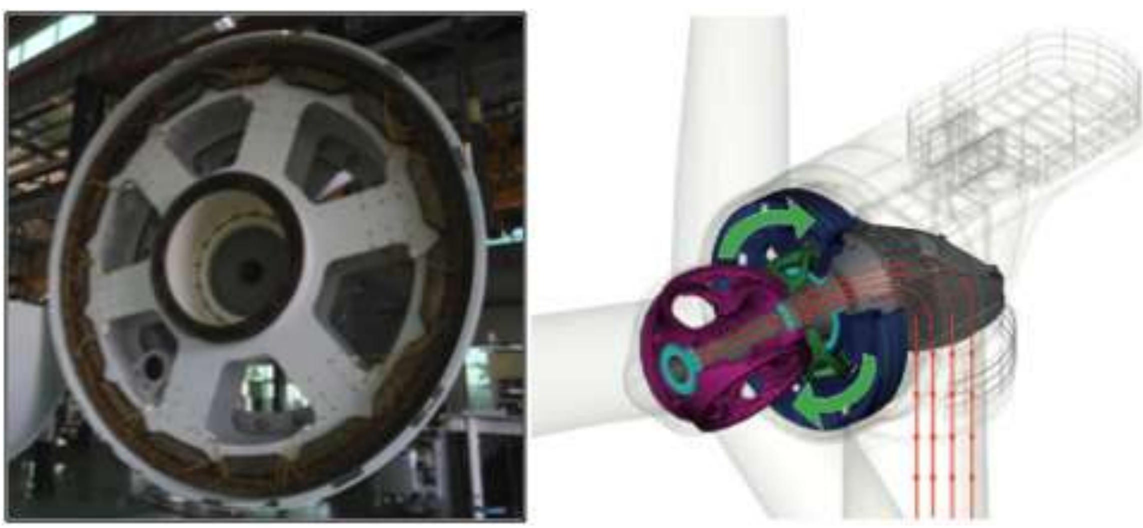


Image 4 Vensis DD generator & Alstom 6MW DD machine

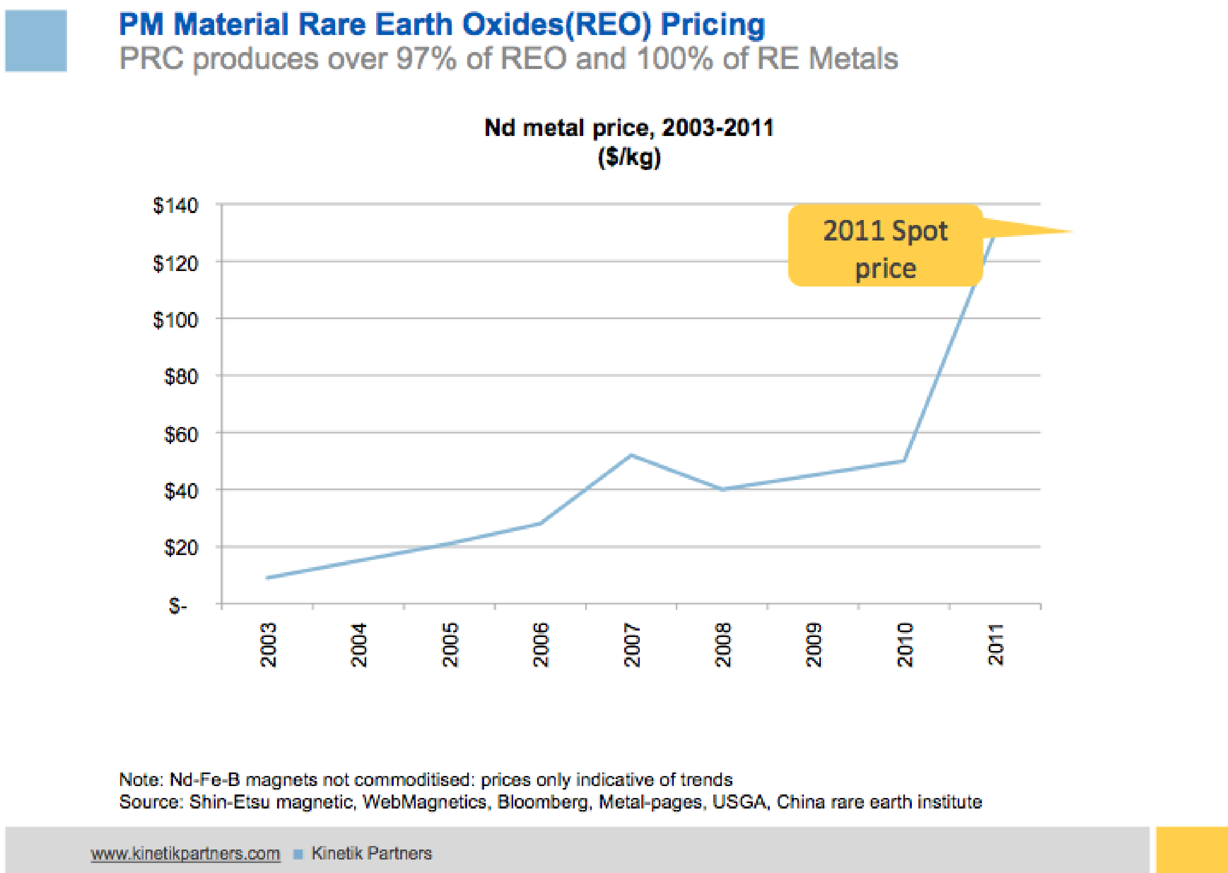
Architectures

The effect of these architecture changes to manufacturing is quite significant. For direct drive, the large diameter and lack of gearbox allows the gearbox housing and mounting to be more integrated into the nacelle structure. Large format casting and forging, and machining will be required for the forward mounting structure, and the generator rotor, stator, and housing. This makes the manufacture of these architectures more complex.

While direct drive machines seemed for a while the great opportunity for the industry they have encountered two issues, (1) issues with the reliability of low frequency converters and (2) the cost of Rare Earth Magnets.

As mentioned before, PMG machines require highly specialized power electronics. These inverters have an inherent reliability problem on direct drive machines due to the low frequency and high power that ring through them.

Secondly, the permanent magnets are used, made of neodymium, typically referred to as “Rare Earth” magnets. These designs were predicated on relatively low prices for rare earth elements prior to 2008. However, with 97% of rare earth element production in China, the supply chain has become quite difficult. China is exerting control over this resource and limiting supply to its own domestic uses. Prices for rare earth elements have risen dramatically since 2009, as shown in the graph below, which has challenged the economics of direct drive machines which rely on rare earth magnets for their generators.



Based on latest technical and market conditions, it appears that the integrated design with a medium speed permanent magnet generator is the most optimized solution for the near future projects. These shall create an opportunity for companies with existing capability in these areas to manufacture high precision heavy fabrication wind components.

New Foundation Concepts

For offshore environments, gravity foundation/tube tower and monopile designs are considered appropriate for water depths up to 30 m. Stiffer, broad-based configurations suitable for development in deeper waters up to 60m include tripods, jackets, mono-towers and jackets, and suction. Mono-tower-and-jacket technology has been used by the oil and gas industry in depths up to 450 m.

Moreover, there is extensive opportunity to leverage existing expertise from ocean engineering, specifically from the oil and gas industry, such as the development of floating turbine structures for deeper waters. These structures would be secured to the ocean floor via catenary guy wires, mooring lines, or taut tension legs, which in turn would be fastened to anchors or gravity-based platforms. Examples of floating turbine configurations being explored in Europe include the Hywind, SwayWAY, BlueH, and WindSea concepts.

Benefits of floating technologies include: a) access to higher wind classes further from shore, b) lower environmental impacts on wildlife and their habitats, c) lesser visual impact and d) onshore production of the platform with the potential for full turbine assembly near shore.

The largest challenges in developing effective floating turbine design include that it must be engineered as a complete turbine-platform system to withstand the coupled aerodynamic/hydrodynamic loading of more severe sea states and higher tower-top accelerations, they will require complete re-engineering to account for the different loading conditions, and engineering design tools are still being developed. In addition, loads on floating turbines may be much more difficult to model accurately.

As the drivers of offshore wind turbines further refine their architecture and design as a function of deeper depths, larger turbine size, and more consistent wind regimes, so too will the foundations used in their construction change. Our technology roadmap foresees the dominant foundation designs will be (1) monopile, (2) tripod, (3) TLP (tension leg platforms), and (4) floating mono structures.

Gravity Foundation 1 STRABAG Offshore Wind GmbH

Tripod ARGE Tripod Borkum West II

Gravity Foundation 2 Hochtief Construction AG

Monopile Erndtebrücker Eisenwerke EEW

source 1 WAB magazine

Monopile Foundation: this design is commonly used in shallower depths (up to 30m), the wind tower is supported by a monopile steel pipe either directly or through a transition piece. The pile is typically driven into the seabed by large impact or vibratory hammers, or the piles are ground into drilled sockets. It is typically comprised of steel pipe pile up to 6 m (20 feet) in diameter with wall thicknesses of 150 mm (6 inches). It is considered to have minimized environmental impact relative to other designs.

Tripod foundation: the tower is mounted to a three-legged steel structure with piles or caissons fixing the turbine to the seabead. These jacket legs are diagonally and horizontally braced to a transition piece in the center. These are typically pre-fabricated on-shore and transported by barge to the site and are more suitable for transitional depths

TLP foundation: At transitional and deep water depths, floating platforms become better foundation options. These structures are assembled onshore and then floated to the site where it is submerged and connected to anchor piles. The entire structure can be disconnected from the anchor piles and floated back to shore for major maintenance or repair of the wind turbine. Platform technology may be adapted for shallow depths as well.

Image 5 Glosten and Associates. TLP Concepts

Floating mono structures: These foundations use floating tower technology and are appropriate at depths of 120-700m. It typically consists of a steel floater that extends up to 100m below water surface and is filled with ballast, then anchored by wires to the seabed.

Type	Max Size (M)	Max Weight (MT)	Max Water Depth (M)
Gravity Base	15	1000	15
Monopile	6	350	40
Tripod	20	150	40

Jacket	15	400	50
TLP	20	400	>50

Figure 13. Foundation type specifications. (source: Malhotra, Design and Construction Considerations for Offshore Wind Turbine Foundations)

Assembly concepts and process

Relative to onshore wind turbines, offshore turbines have higher capital costs due to adaptations and upgrades for sea operation, foundations, balance-of-plant, installation and interconnection. In addition, significant capital investment is required to develop the infrastructure necessary to support the offshore industry, including: vessel production, port/harbor adaptation, manufacturing infrastructure, and qualified workforce.

To date, most offshore wind foundation structures have been appropriate for shallower waters, up to 30m, using gravity and monopole design. In deeper waters, more appropriate technologies such as tension leg platform (TLP) and mono floating structures (or spar buoy) simplify the foundation process and are preferred.

On site marine construction can be four to eight times more expensive than the sam e workperformed in a factory environment[2]. Specialized at-sea equipment, barges and ships can require significant investment in local shipbuilding and maintenance and repair infrastructure.

[2] UNIVERSITY COLLABORATION ON WIND ENERGY, Cornell University, Alan T. Zehnder and Zellman Warhaft

High-level assessment of Maryland steel fabrication capabilities

Kinetik conducted a broad assessment of Maryland Steel related industries. We focused on three areas: production, fabrication, and shipyards. The following section includes an assessment of the state's capabilities to support the offshore wind steel production and fabrication requirements for the nascent US wind offshore industry.

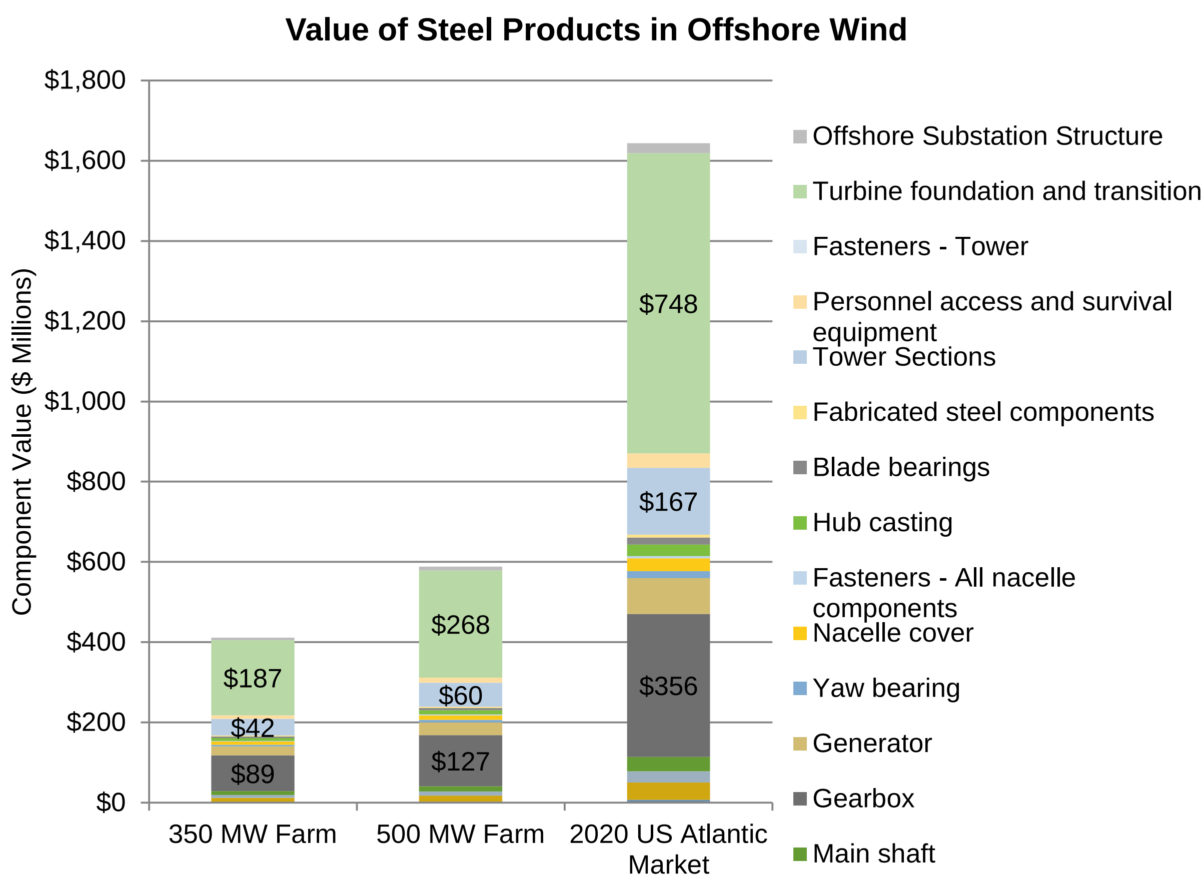
Component Opportunity

The primary components presenting a large opportunity for the Maryland steel industry for offshore wind are: foundation structures and transition pieces, tower sections, large castings, and large steel fabrications. Kinetik Partners identified these component opportunities for Maryland based on our Work Breakdown Structure analysis for steel component values, together with our analysis of steel fabrication in Maryland and the capabilities of high relevancy companies.

The following Chart shows the market value of each of the 16 main steel based components in three different wind farm or market scenarios: 350 MW farm, 500 MW farm, and the 2020 US Atlantic Market. The highest value components are the gearbox, the tower sections, turbine foundation and transition components. The gearbox itself is made up of several smaller components, such as gears, shafts, and housing.

Steel supply, Foundation Structures, Transition Pieces, and Tower Sections

These three components are all highly related in that their primary construction is thick plate steel rolled into circular sections and welded, with successive sections welded or bolted together. Also, these components are incredibly steel intensive, making up a large portion of an offshore wind project's value, and also representing a high proportion of the mass of each turbine system. Maryland companies also possess the ability to make these components. RG Steel could do the construction of these pieces directly, by an independent supplier using RG Steel product, or a joint venture. An investment of approximately $100 Million would be required to install the equipment necessary to roll plate steel into the large diameter sections and weld the steel loop together and weld adjacent sections to each other.



Steel Supply

Manufacturing of these high value, high dollar components is attractive for the Sparrows Point site based on its proximity to the raw material supplier (RG Steel), which thus reduces logistics costs and also its proximity to ports and the sea. The tower sections are currently shipped by rail and truck for onshore wind projects, but the growing tower sizes for growing turbines will not likely ship overland, even by rail. Eventually, it will be mandatory that the offshore towers be manufactured on or adjacent to a site with access to a port. The offshore monopile foundations and transition sections are already too large to be manufactured inland and shipped to ports, even if the added logistics costs were justifiable.

The option to capture the highest level of the offshore wind turbine value chain is to develop a cluster of ventures whose competencies could address all the needs, which would be anchored by RG Steel based on its supply capabilities, willingness to invest to capture burgeoning markets and logistical and space advantages. In the near-term, RG Steel and other Maryland-based companies can address offshore market needs through various permutations of the supply chain. An obvious example is for RG Steel to be the dominant supplier of raw or semi-finished material into the value chain (which will be discussed below). Another option is to import semi-finished material and conduct “major transformation” activities such as roll forming; in this situation Maryland loses out on a significant portion of the raw material value in the offshore WTG value chain, but captures more labor-intensive activities. In the end, our recommendation will be to concentrate as much activity as possible within the state of Maryland in order to maximize economic development.

Toll Processing

Toll processing is the act of processing steel for a fee (“toll”). Owners of the steel may not possess the facilities to perform needed operations on the material (or may not have the open capacity). Therefore, another steel mill or service center will slit, roll, coat, anneal, or plate the metal for a fee. Using a toll processing arrangement may be a method to maintain as much value within Maryland's supply chain as opposed to importing product from another state or country. For example, since RG Steel's plate rolling capabilities do not meet the specifications for wind tower components, RG Steel may still be able to participate in the supply chain by supplying the steel slabs from which the plate is rolled.

RG Steel is an integrated steel mill, which means it casts slab from its raw materials: iron ore, metallurgical coke and alloys. Thus, RG steel can participate in a large portion of the steel supply chain from an early stage. A toll processing agreement could then be arranged either outside of Maryland, since no slab rolling processors reside within the state, or a toll processor could be attracted to locate within Maryland based on a long term agreement with RG Steel. Incremental logistics costs for these types of arrangements can often be offset by volume and long-term agreements.

Towers

As of today, RG Steel would have to invest significant capital and time to have the capability to supply plate or cast products to the specifications required for offshore wind turbine manufacturing; it can only roll up ½" thick finished steel coil, which is too light of a gauge for wind towers. However, RG Steel can supply thicker steel slabs which can then be toll processed to the correct specifications. RG Steel has toll processing capabilities under existing relationships with ArcelorMittal Steel, but outside of Maryland, specifically in Coatesville and Conshohocken, PA. In addition, RG Steel has expressed that there exists the embedded forming and welding capability near the Baltimore area. Moreover, RG Steel has the capability to supply steel slab to the correct chemistries, as it exports rolled products to European markets. Lastly, RG Steel's ability to perform micro-runs adds a low cost flexibility as the industry ramps up from small to large. With slab constituting approximately 50% of the final value of the tower, the addressable market opportunity for RG Steel through slab supply alone is upward of $80 Million.

Foundations and Transition

Foundation and transitions are typically supplied by the same vendor. Depending on the type of foundation chosen, the addressable market opportunities could be similar to the tower opportunity; such as monopile foundations. Again, RG Steel would be considered the top potential supplier in this category, whether supplying slab to be re-rolled and welded in monopile, TLP, and floating monopile technologies, or coil to be formed into tubular products to be welded together into jacket and tripod technologies. While the ability to manufacture turbine towers, foundations, and transition pieces does not currently exist, there is a ready ability to expand current operations for RG Steel, or for another company with heavy steel rolling expertise to locate in Maryland to produce these components. This presents a very large economic development opportunity for the State of Maryland to either support an RG expansion, or to help attract a high value supplier and employer to the state.

Example of Immediate MD Supply Chain Capability – Transition Piece

Example of Immediate MD Supply Chain Capability – Monopile/TLP/ floating Monostructure

Example of Immediate MD Supply Chain Capability – Tripod/Jacket

The addressable market opportunity for RG Steel alone, depending on the type of technology employed, could range from $240 Million to $400 Million in this category alone.

Large Castings – Bedplate, Cast Nacelle Structures, and Rotor Hub

The Bedplate and Cast Nacelle structures are the main structural components in the wind turbine holding the drivetrain, and mounting onto the tower. The Rotor Hub attaches the blades to the drivetrain, transmitting the torque of the blades. (Reference Pictures below of bedplates, hybrid structure, and hub). These components represent the 4th and 6th most value components in the wind turbine based on our Work Breakdown Structure and component value assessment.

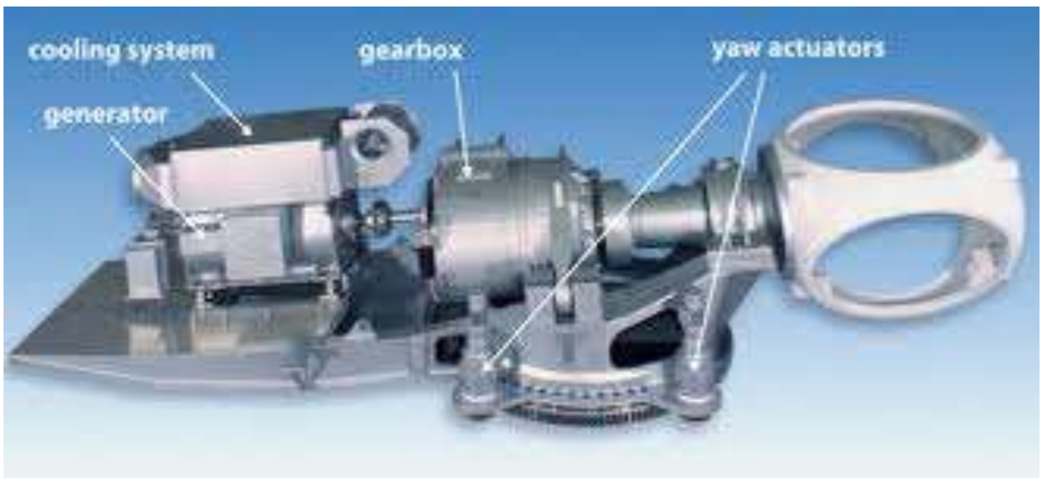


Image 6: High Speed Wind Machine Bedplate and Drivetrain. Source: Energy Research Center Netherlands

Maryland companies possess the capability to expand into these components, but none are currently able to do so. RG Steel is the primary company with the ability to cast these large and complex structures, and our conversations with senior management have revealed that RG Steel is generally interested in adding large castings to its product portfolio. Investment for large casting capability is around $20-$40 Million, including the machinery and equipment to machine the large pieces. If RG Steel is ultimately not interested in casting the components, there is ample opportunity for independent suppliers or joint ventures to develop this capability.

While bedplates and rotor hubs for onshore wind turbines are currently readily transportable overland via truck and rail, the inherently larger offshore machines are growing ever larger, and the changing architectures dramatically affect the size and mass of the structural components. We expect that it will become most practical to cast and machine these large pieces in coastal locations with ready access to ports. As such, Sparrows Point is an attractive location for manufacturing bedplates, large structures, and rotor hubs.

Figure 14: Cast and Machined Bedplate, image below. Source: K&M Machine Fabricating

Source: Renewable Energy World

Large Steel Fabrication

Large steel fabrications make up a relatively small portion of the wind farm cost (.19%), but are a good fit with the Maryland Industrial Composition. Also, when paired with a specific type of large fabrication - Personnel access and survival equipment (.94%), large steel fabrications are on par with the value of large castings. Canam Steel and Miscellaneous metals are two attractive companies for applying their expertise in fabricating large structural steel components to offshore wind. Examples of steel fabrications include met tower structure, offshore substation structure, turbine ladders, cages, catwalks, railings, and fabricated portions of the nacelle structure attached to the bedplate.

Image 7 Large Fabrications. Ambau port location. Source WAB Magazine

Canam Steel has demonstrated its expertise in structural steel fabricating recently with its supply of the steel for the New York Mets baseball stadium, Citi Field.

Addressable Market

As per the component opportunities previously discussed, there are immediate or near-term markets within the offshore wind turbine manufacturing value chain, which can be addressed. We will discuss these in four large supply categories: steel supply, heavy fabrication and assembly, components, and services. The value of this market will pass $1.6 Billion by 2020.

Maryland Steel Fabrication Capabilities

An offshore wind steel cluster would provide ample opportunity for new investment and expanded business along several axes.

The breakdown of the full list of companies shown below, illustrates Maryland's strong base of manufacturing capability in the full spectrum of steel working. The tables on this section show a breakdown of companies by capacity to support and compete in the offshore wind supply chain.

An analysis of the exhaustive and detailed company lists shows that Maryland has very high capability in steel production and fabrication, steel product manufacturing, and steel construction. With 254 companies overall identified in our search, and 65 companies fitting our more targeted criteria, Maryland has a very strong base of steel capabilities, which puts the Maryland steel industry in a good position to provide steel products to the US offshore wind industry along the Atlantic Coast.

In addition to number of companies active in the steel value chain, company revenue is a critical indicator for a company's ability to serve the offshore wind value chain. Figure 17 below, shows the top 10 companies by revenue of the most highly relevant companies to offshore wind.

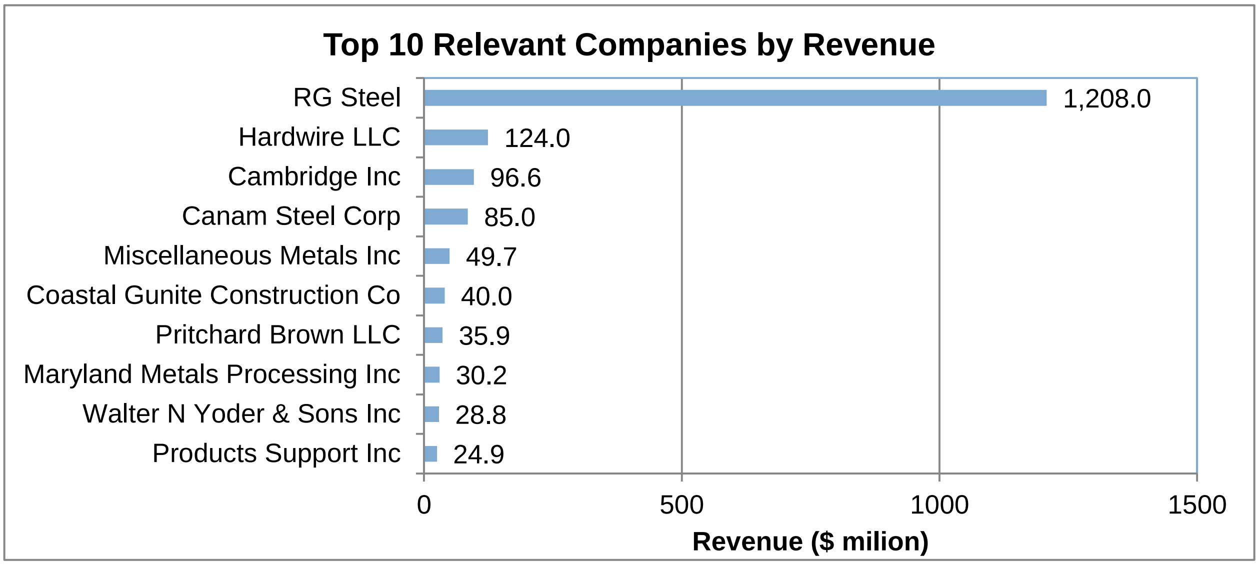


Figure 15 Top 10 Maryland steel production and fabrication companies

RG Steel is by far the largest company by revenue, with over $1.2 Billion in sales according to OneSource. RG Steel at Sparrows Point is the successor, via a few acquisitions and ownership changes over the last decade, to Bethlehem Steel, which operated the mill at Sparrows point from 1916 until the early 2000's. As a steel producer, the presence of RG Steel provides the opportunity for a very strong anchor to a vibrant and diverse steel industry based in Maryland for the offshore wind market starting with raw steel. RG Steel can also diversify its operations from rolled steel manufacturing to large steel castings such as bedplates and other heavy nacelle structures, and rotor hubs. In addition to RG Steel, there are several mid-sized companies with the capability to participate in a Maryland offshore wind steel cluster as steel product manufacturers or suppliers, either in a direct relationship with RG Steel as part of a steel supplier park, or more autonomously. In addition, there are additional medium-sized companies able to participate in the offshore wind market, plus many smaller companies with the ability to find niches in the offshore wind value chain.

Heavy Fabrication

The heavy fabrication portion of the steel value chain can be conducted by several Maryland-based firms. The following Maryland firms can currently participate in the heavy fabrication portion of the offshore wind value chain:

Company	Description
Cambridge Inc	Wire products
Canam Steel Corp	Joist and structural supply
Walter N Yoder & Sons Inc	Pipe and metal fabrication
Pico Industries Inc	Steel fabrication and welding
Free State Steel Inc	Rebar and structural steel supply
Standard Supplies Inc	Structural steel supply
Victory Steel Co	Rebar Supply
Hardwire LLC	Military and civilian composite ballistic armor solutions
Maryland Metals Processing Inc	Steel plate, sheet supply and fabrication
Bws Industries Inc	Steel welding services
Pro-Fabricators Inc	Custom fabrication
Beltway Iron Co Inc	Miscellaneous metal fabrication
Fairlawn Tool & Die Co Inc	Metal fabrication services
Steel Specialties	Custom fab and structural steel supply
Congressional Iron Works Inc	On site welding
Diamond Iron Works Inc	Steel flat products service cente
Dietrich Metal Framing	Metal framing and building systems
Macon Metal Inc	Sheet metal fabricators

The value of this portion of the supply chain in Maryland, focusing on towers and foundation alone could be $60 to $240 Million depending on the level of activity and engagement.

Components

The component opportunity is dependent on the specifications of the individual components, and the level of machining and milling which would be required to manufacture these components. That being established, the following companies are a sub-set of manufacturers who have potential competency in the component level of the offshore wind turbine value chain

Company	Description
Simpson Strong-Tie Co Inc	Fasteners, screws
Canam Steel Corp	Joists
Miscellaneous Metals Inc	Light structural, railings, gratings
Pritchard Brown LLC	Weatherproof enclosures, shelters
Jarvis Steel & Lumber Co LLC	Steel joists, decks, erection
Indusco	Wire rope and fittings, riggings
Products Support Inc	OEM products
Dietrich Metal Framing	Metal framing and building systems
Chicago Metallic Corp	Ceiling systems and roofing products
LAI International Inc	Advanced machining and precision products
Chesapeake Machine Co	Machining, milling, fabrication

Services

Services in the offshore wind manufacturing value chain would include labor-intensive activities, logistics, port, water transport and other project-related expenses. Specific Maryland-based companies which could participate in the service portion of the value chain immediately include:

Company	Description
MTD Erectors Inc	steel building erectors
Quality Erectors Inc	steel building erectors
Merit Builders Inc	steel building erectors
Eastern Steel Constructors	steel building erectors
Tri-State Steel Erectors Inc	steel building erectors
A Able Security Ironworks Inc	construction services
Port of Baltimore	Port, warehousing, logistics, stevedores
Kinder Morgan	Port, warehousing, logistics, stevedores
Rukert	Port, warehousing, logistics, stevedores
APM	Port, warehousing, logistics, stevedores
Transcom	Port, warehousing, logistics, stevedores

Port of Salisbury	Port, warehousing, logistics, stevedores

Key Maryland Company Assessment

RG Steel

RG Steel is the top recommendation to engage with the development of offshore wind steel supply. Located in Sparrows Point, RG steel was recently formed in March 2011 out of assets formerly from Bethlehem Steel via Severstal. It is the only fully integrated steel mill located on the US East Coast. It is accessible by rail (owning its own short line railroad), truck, or ship (having a deep-water port with direct ocean access to facilitate imports of raw materials and exports of finished products). Its capabilities include:

- 1 blast furnace
- 1 two-vessel basic oxygen furnace
- 1 dual-strand caster
- 1 hot strip mill
- 2 cold mills
- 2 tin lines
- 3 coating lines

It has the capacity to annually produce 3.4 million tons of steel, 3.4 million tons of hot-rolled band, 1.5 million tons of cold rolled coil, 600,000 tons of galvanized product, and 660,000 tons of tin and black plate products. The hot strip mill can roll gauges up to 0.495" thick, in widths up to 61". Its cold mill can produce thicknesses from .014" through .099" in widths from 30" to 60". The plant's coating capabilities include two separate galvanizing lines, each with a width 48". Its ability to supply slab for downstream rolling products to European specifications, in our view, is key to the development of an offshore wind turbine supply chain within Maryland.

Cianbro Corporation

Cianbro Corporation is a diversified construction company and infrastructure contractor based out of Pittsfield, ME, with a regional office in Baltimore, MD. Cianbro offers construction services including design, implementation, start-up, commissioning and turn-key operations. Its activities which hold relevance to the offshore wind value chain are cable splicing, caissons, deep foundations, electrical, piping, instrumentation & control work, lighting, piling, welding, power line construction, rigging, substation construction, tower installation, transmission and distribution. Its relevant fabrication services include structural steel, construction materials, beams, columns, industrial coatings, metals and plate work. It is uniquely prepared to advise or supply a wide scope of services to the offshore wind value chain.

Hardwire LLC

Hardwire LLC could provide expertise in the assembly, fabricating and welding of large wind turbine components. Its experience providing reinforcing solutions for large infrastructure projects and its metallurgy expertise is considered a competency fit. It provides reinforcing solutions for military vehicles, blast resistant structures, automotive composites, infrastructure armor solutions, marine laminates, concrete repair retrofits, flooring, storm resistant structures, ballistic-resistance panels, reinforced piping, and many other applications. Hardwire technologies are used to protect critical structures against damaging threats. It is located in Pocomoke, MD.

General Ship Repair

General Ship Repair is located in Baltimore, MD and is a full service ship repair yard. Its potential supply chain contribution resides in its on and offshore assembly, welding, and fabricating competencies. It has dry dock and wet berth services, floating cargo equipment, and an industrial metalwork division. Servicing tug boat and barge repair. They are a fully integrated facility capable of performing repairs, conversion and construction on vessels. Its floating drydock can accommodate vessels of 1200 tons displacement with 60 ft. between wing walls and a flat keel of 192 ft. Its Baltimore Metal Works division works with carbon steel, stainless steel, aluminum, and specialty metals. Baltimore Metal Works (BMW) is highly skilled in using all types of ferrous and non-ferrous metals. The BMW division offers commercial/industrial customers metal fabrication services, and machine shop and pipe shop work. Additionally, it provides specialized field and shop repairs. It employs machinists, riggers/erectors, mechanics, metal fitters, crane operators, sheet metal mechanics, certified welders/burners, pipe fitters and other laborers.

Chesapeake Shipbuilding

Chesapeake shipbuilding could provide competency and expertise in the foundation, assembly, and welding portion of the offshore wind turbine value chain. Located in Salisbury, MD, Chesapeake Shipbuilding is a naval architecture firm with over thirty years of direct industry experience, specializing in the design and building of commercial ships up to 375 feet in length: vessels, tugboats and ferry boats, luxury small cruise ships, oil supply boats, restaurant boats, and passenger and vehicle ferries. Their coastal cruise ships are the largest built to meet U.S. Coast Guard Subchapter K and/or SOLAS regulations. Chesapeake Shipbuilding's construction yard is located on 13 acres with nearly 2000 ft. of deepwater bulkhead along the protected waters of Maryland's Wicomico River. They have 2 construction basins, 3 level construction/side launch systems, plus a ground transfer system and various hull fabrication buildings and shops. They have added 2 new hull fabrication buildings for the construction of tugs in a controlled environment equipped with automatic welding equipment, a compressed air system, and a rail system that allows vessels to be moved to the launch ways.

CanAm Steel

CanAm Steel is located in Point of Rocks, MD. CanAm Steel manufactures galvanized siding, steel joists, structural steel components, and decking. The company has steel fabrication plants in Florida, Maryland, Missouri, and Washington.

Its materials have found their way into Montreal's Pierre Trudeau International Airport, New York's Citi Field, and the Cincinnati Zoo. It can provide heavy fabrication competency to the offshore wind value chain.

Walter Yoder & Sons

Walter Yoder & Sons is located in Cumberland, MD and can provide expertise on pipe and tubing to the offshore wind value chain. Its capabilities include custom fabrication of gauge metal to 3.5" thick, plasma table and pipe layout and cutting equipment within a 25,000 SF shop space, and servicing carbon steel, stainless steel, aluminum, titanium. They fabricate pipe, ductwork, and miscellaneous metals for installation. Its shop capabilities include rolling, shearing, arc plasma cutting, bending, painting and sandblasting.

Maryland Company Search (NAICS code analysis)

Kinetik sought to create a detailed list of companies in Maryland that have the potential to serve the offshore wind industry. We identified the NAICS codes related to steel content in the offshore wind value chain, conducted database searches to identify companies listed in Maryland for the relevant NAICS codes, and then analyzed the list of companies based on capabilities and company size.

We approached the NAICS code analysis from two perspectives. First, by reviewing existing literature, and second by applying our own expertise to add to and refine the NAICS codes found in the literature review. We utilized two publicly available reports to begin our NAICS code analysis: a report from the Renewable Energy Policy Project, “Wind Turbine Development: Location of Manufacturing Activity”, and “Wind Turbine Design Cost and Scaling Model” by NREL authors L. Fingersh, M. Hand, and A. Laxson. The REPP assessment was done by identifying the NAICS codes for each of the main components of a wind turbine. REPP analysis revealed two 6-digit NAICS codes for steel work for wind turbines: 331511 – Iron Foundries, and 332312 – Fabricated Structural Metal. This study was helpful, but incomplete. With the value of a wind turbine comprising 41% steel intensive products, and 8,000 total components, there were certainly more NAICS codes describing the steel product content in wind turbines. The NREL Report identified seven NAICS codes for steel product content:

NREL NAICS Codes for Steel Products in Wind Turbines	
NAICS	**Description**
332722489	Other externally threaded metal fasteners, including studs
3315113	Ductile iron castings
332991P	Bearings; Industrial high-speed drive and gear
333612P	Speed Reducer, i.e, gearing
3315131	Cast carbon steel castings
331221	Rolled steel shape manufacturing - primary products
BHVY	Other Heavy Construction

Both the NREL and REPP reports present limitations for the scope of work in this study. They both focus on as detailed NAICS codes as possible to describe the exact components. The more digits in the NAICS code, the more specific the classification. When trying to classify the existing supply chain, this seems to be a rational approach. However, when trying to identify firms that could enter the supply chain based on capability and not necessarily on exact existing product, too much NAICS details will exclude too many firms. In addition, these reports focus on the turbine only, not the activities associated with developing the project, installing the turbines, and connecting the product to the grid. Further, these studies are onshore focused, and so do not shed light on the marine construction aspect of offshore wind development.

Kinetik Partners conducted its own NAICS code analysis based on our understanding of the value chain. Our approach was to first broaden the NAICS code search by focusing on the highest relevant level of the NAICS code hierarchy (higher level =

less digits, more general product classification). For Instance, the 5-digit NAICS code 33151 is described as Ferrous Metal Foundries, and it has three 6-digit classifications beneath it: 331511 – Iron Foundries, 331512 – Steel Investment Foundries, 331513 – Steel Foundries (except investment). All three of the 6-digit categories are relevant, so we used the 5-digit level to capture all three. This higher level analysis allows us to focus on capabilities employed in delivering products, rather than the exact form of the products themselves. This view is critical for identifying companies which could broaden their product portfolio by diversifying into a new market or industry like offshore wind.

Building on our wind value chain knowledge and the existing reports, we conducted keyword searches within the OneSource database for "Steel Iron Ferrous Fabricating" and "Metal Fabricating" to identify further NAICS codes relevant to steel fabricating activities for offshore wind. Also, a review of NAICS codes at www.census.gov/naics/ was conducted under section "31 – Manufacturing" and "23 – Construction" to identify further NAICS codes for steel manufacturing and fabrication.

Our analysis identified 11 NAICS codes for steel product content in offshore wind turbines, as well as offshore construction and port operations that are critical for wind project support.

NAICS Codes for Steel Products in Wind Turbines	
NAICS	Industry Description
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing
3366	Ship and Boat Building
33111	Iron and Steel Mills and Ferroalloy Manufacturing
33122	Rolling and Drawing of Purchased Steel
33151	Ferrous Metal Foundries
33211	Forging and Stamping
33231	Plate Work and Fabricated Structural Product Manufacturing
48831	Port and Harbor Operations
238120	Structural Steel and Precast Concrete Contractors
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing

332999	All Other Miscellaneous Fabricated Metal Product Manufacturing

The NAICS code list was used to conduct NAICS code based searches in OneSource to build a list of companies in Maryland described by those codes. Our analysis found 254 companies in Maryland relevant to steel products in offshore wind turbines, plus the port and construction operations. This list was reduced using a combination of a company's capabilities based on their current operations and sales revenue. Starting with a breakpoint of $10 Million in annual revenue, companies above and slightly below that threshold were reviewed for the most basic potential for entering wind turbine supply. For instance, Pacific Bridge Inc. was listed under 33151 – Ferrous Metal Foundries, but in fact is an HR firm. Then, all companies above the threshold were reviewed via web and OneSource searches to understand each company's capabilities. This analysis yielded a reduced list of 65 companies. A top 6 list was further identified by looking at the top overall companies by revenue from the reduced list, and understanding a company's relevance to the offshore wind supply chain.

Number of Maryland Companies in Each NAICS Code	
Industry Description	Total
Plate Work and Fabricated Structural Product Manufacturing	85
All Other Miscellaneous Fabricated Metal Product Manufacturing	44
Ship and Boat Building	27
Structural Steel and Precast Concrete Contractors	24
Iron and Steel Mills and Ferroalloy Manufacturing	21
Forging and Stamping	20
Engine, Turbine, and Power Transmission Equipment Manufacturing	10
Ferrous Metal Foundries	10
Search for "Port" in the business description	7
Rolling and Drawing of Purchased Steel	4
Port and Harbor Operations	1
Bolt, Nut, Screw, Rivet, and Washer Manufacturing	1

Figure 16 Maryland companies with capabilities on steel production and fabrication per NAICS

Analysis of the economic opportunity for Maryland business

Maryland is in an enviable position to become a major player in the offshore wind industry. The US will need over 10,000 MW of offshore energy production to meet the US Department of Energy targets. Similarly, Maryland would require approximately 1,000 MW to meet 25% of its 20% renewable portfolio standard mandate.

The Maryland steel sector is well placed to benefit from investments flowing into the offshore wind sector, by capturing some share of installations due its offshore wind conditions and the ability to complete some preemptive investments in the steel production and fabrication industry.

In this analysis we will calculate the possible benefits of a strong US offshore industry, and the employment of different economic development strategies to maximize domestic component supply and selective investments that increases barriers of entry to other regions.

Scenario Analysis

The scenario analysis indicates the economic opportunities for Maryland based business on three drivers: political support, local content and regional export business. We see three potential scenarios:

Base Scenario

This scenario assumes clear political support for wind energy, market leadership in offshore development, in the mid-Atlantic, becoming a strong supplier of material and fabricated components, and achieving a limited degree of export.

Aggressive Investment Scenario

This scenario assumes stronger political support for wind energy, preemptive investments in material production and fabrication, becoming a leading exporter of materials and fabricated components for floating platforms, and securing some market share in the development of vessels.

Passive Investment Scenario

This scenario assumes a lack of political support for wind energy, failure to achieve leadership in offshore fabrication, and the absence of significant manufacturing within Maryland steel production that would lead to significant imports and limited exports.

The likely success of these scenarios will depend on the ability to develop strong working relationships between the state of Maryland, regional partners and the steel industry. Should this public-private partnership be able to overcome market and political barriers while anticipating investments required to launch new technologies and product platforms, the high market penetration scenario could be very possible.

Creating the opportunity for Maryland's steel industry

The state government and industry have taken steps to facilitate future growth; such as enacting an aggressive RPS, engaging with key stakeholders (e.g., trade unions, employers) and studying the state's capabilities to compete in a global industry. Our conclusions are based on discussions with industry experts and our own analysis, and we present a set of recommendations to leverage public and private support.

Maryland companies have the potential to secure a large share of the steel production and fabrication required to grow the US offshore wind industry. We propose three areas of action that match the Maryland's strengths with current and future industry needs.

Steel production and fabrication

The fabrication of steel components should be the primary target for Maryland companies. While the market opportunity is substantial, so is competition due to the fact that capital requirements to enter this market are low. Therefore, policymakers should focus on large components that require long learning curves, such as specialized foundations. Additionally, the development of alternative steel supply agreements, such as aggregate buying and consignment orders, would be beneficial to take advantage of this opportunity. Lastly, developing a cluster of service operations at the Sparrows Point campus would offer a logistics advantage relative to competitors' supply sites, and thus would give Maryland steel fabricators a further advantage.

Castings

With some incremental investment, policymakers and industry should form a consortium to develop a full service foundry with onsite machining at Sparrows Point. To date, there are only three large casting facilities supplying the US wind market. None of these are competitive, mainly due to the use of old processes and lack of integrated machining on site. The integration of the latest lean manufacturing methodology with technological advances in casting and cryogenic machining could secure large market share for cast components.

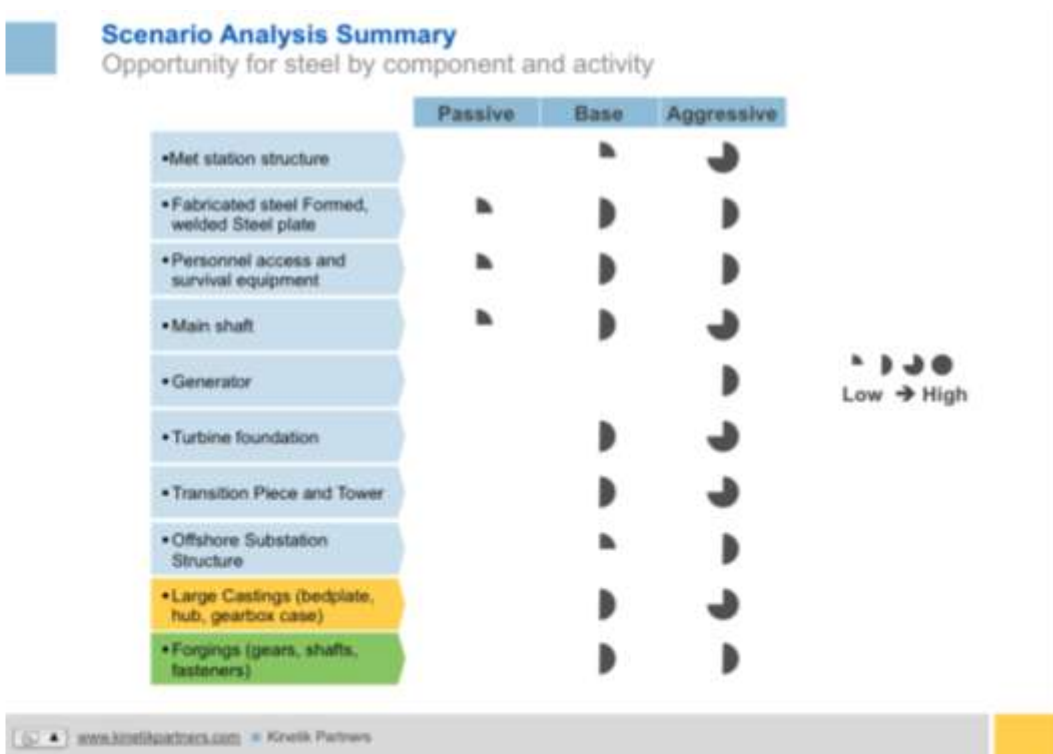
Specialized Shipbuilding

Based on analysis of vessel requirements in northern Europe, we believe that achieving the US DOE's goal 10 GW installed will require the construction of a minimum of twenty-five (25) new specialized vessels. These specialized vessel prices can range between $100-150 million. The presence in Maryland of one of the seven active shipyards on the Eastern seaboard presents an opportunity to partner with a

European ship designer and/or operator to secure the construction and commissioning of these specialized vessels.

Scenario Analysis: Results

Kinetik developed three scenarios based on different levels of investment to grow regional capabilities. The image below subjectively quantifies the opportunity based on capabilities and investment by component.



Passive Scenario

The passive scenario shows poor results. Assuming limited sales to potential Maryland projects and other regional projects, this path shows minimal incremental sales reaching $20 Million by 2025.

Types of components:

- Fabricated steel Formed, welded Steel plate

- Personnel access and survival equipment
- Main shaft

Base Scenario

The base scenario shows significant promise with limited investment. It is contingent upon developing a strong cluster of services at Sparrows Point including partnerships with existing offshore companies or new market entrants. Policymakers and industry should focus on developing heavy fabrication, forgings, casting and machining capability.

Within this scenario, policymakers and industry use small investments to upgrade Sparrows Point's infrastructure to attract a wide scope of offshore wind service companies. In turn, this minimizes logistics costs through co-location and ensures that the cluster is competitive. Roll forming equipment will most likely need to be acquired to execute this strategy.

Investments in small forging and coating capabilities can provide access to fastener and other existing component OEMs as a tier 3 supplier. This could be done by, or in partnership with, local companies or through the attraction of a diversified specialty fastener company.

Additionally, foundry and machining equipment could open opportunities for the development of large castings for the wind industry in small volumes

Types of components

- Met station structure
- Fabricated steel Formed, welded Steel plate
- Personnel access and survival equipment
- Main shaft
- Turbine foundation
- Transition Piece and Tower
- Offshore Substation Structure

- Large Castings (Bedplate, hub, gearbox case)
- Forgings, Gears, shafts Fasteners

This scenario could bring over $650 million by 2025 and between 3,500 to 5,000 jobs to the region.

Aggressive Scenario

The aggressive scenario shows significant market share opportunities for Maryland companies. However, it will require higher investment levels and coordination between industry players. A strong integrated cluster will need to be developed around the Sparrows Point complex providing the capability to competitively supply offshore wind components in partnership with a key offshore company and a new entrant.

The evolution of the offshore wind energy supply chain presents an entrance opportunity for Maryland companies. During early stage growth markets, OEMs tend to vertically integrate to minimize supply risk from underdeveloped portions of the supply chain. As markets mature and supply chains develop fully, OEMs tend to divest non-core assets and components to focus on core business activities. For example, Vestas has been traditionally one of the most vertically integrated OEMs. While this strategy has helped during high growth years, overcapacity in slow growth years has hurt the company financially. Today, they are looking to divest from most non-core business.

Maryland policymakers and industry should focus on securing partnerships to shift full production from an OEM-operated, vertically integrated facility to a cluster-operated site. The investment should focus on acquiring or developing competencies or acquiring divesting assets which serve heavy fabrication, forgings, casting and machining.

The aggressive scenario will require investments to upgrade the Sparrows Point's infrastructure to minimize logistics costs and increase competitiveness. Necessary infrastructure investments include docks, staging areas and enclosed fabrication facilities.

Investment in large roll forming and welding equipment will be necessary to secure significant foundation and transition piece contracts.

Foundry and machining equipment could open opportunities for the development of large castings in medium to large volumes. The addition of machining equipment could provide opportunities to fabricate large components such as generator stators and cases, as well as gear machining.

Investments in small forging and coating capabilities can provide access to other component OEMs, such as fasteners. This could be done through local companies or by attracting a specialty fastener company to the site.

Types of components:

- Met station structure
- Fabricated steel Formed, welded Steel plate
- Personnel access and survival equipment
- Main shaft
- Generator components
- Turbine foundation
- Transition Piece and Tower
- Offshore Substation Structure
- Large Castings (Bedplate, hub, gearbox case)
- Forgings, Gears, shafts Fasteners

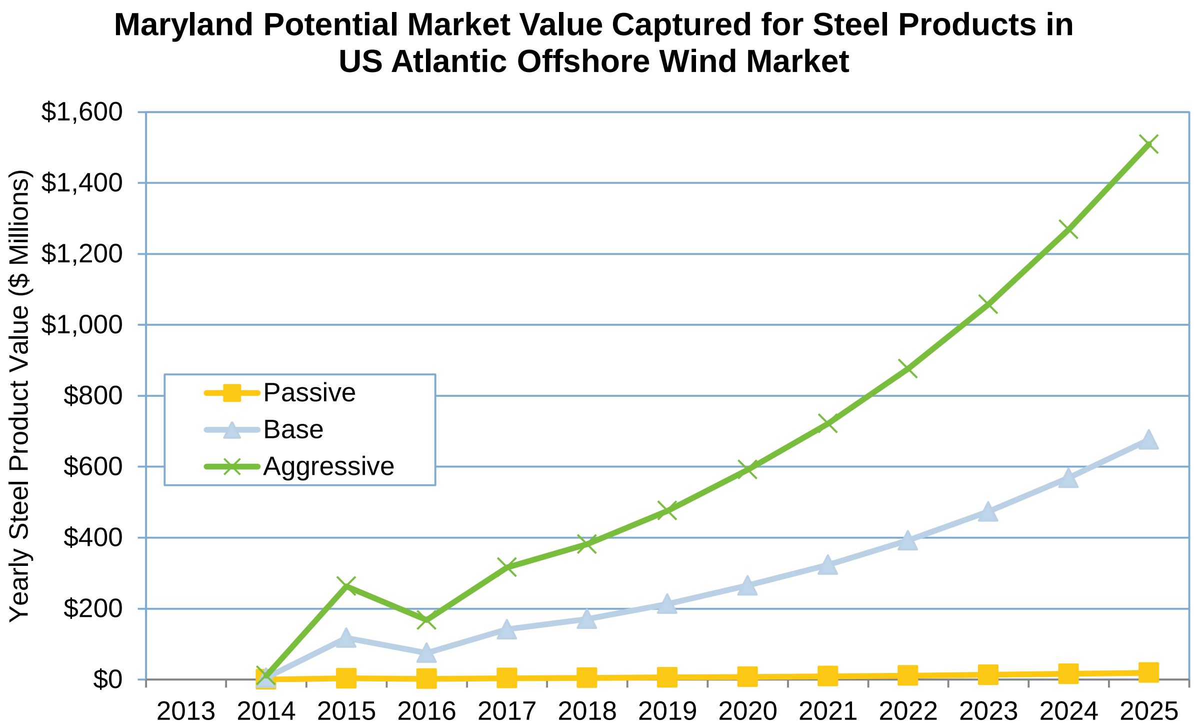
This scenario could bring over $1,500 Million by 2025 and between 6,000 to 8,500 jobs to the region.

Specialized Shipbuilding

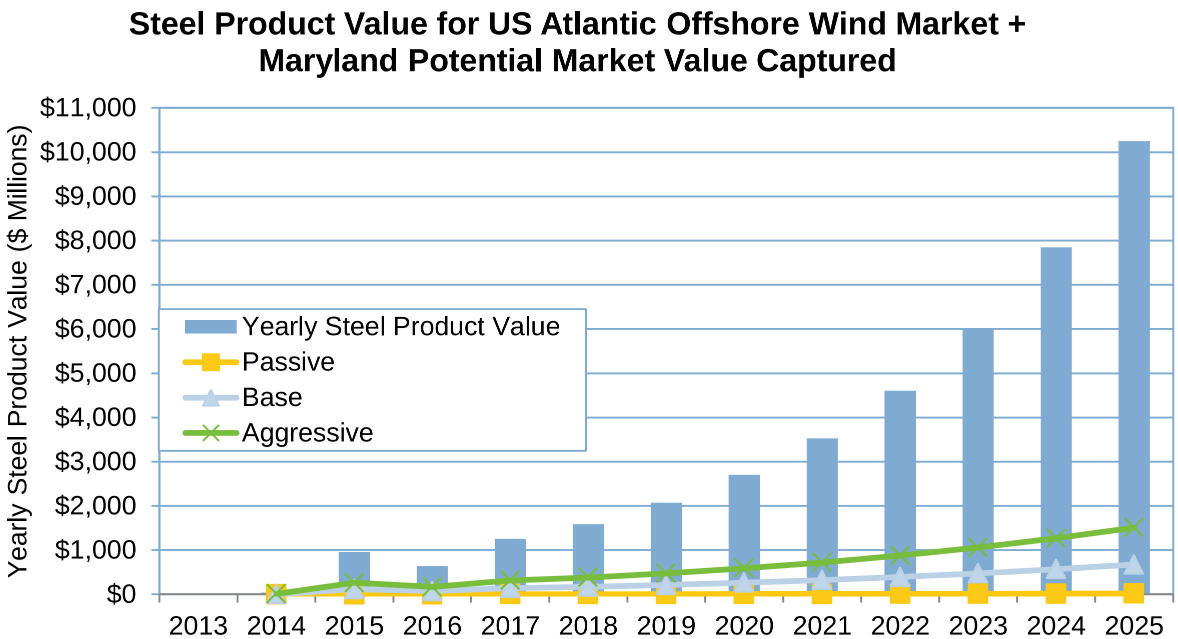
Building multiple specialized vessels would bring an additional $200-300 Million to the region.

Scenario Comparison

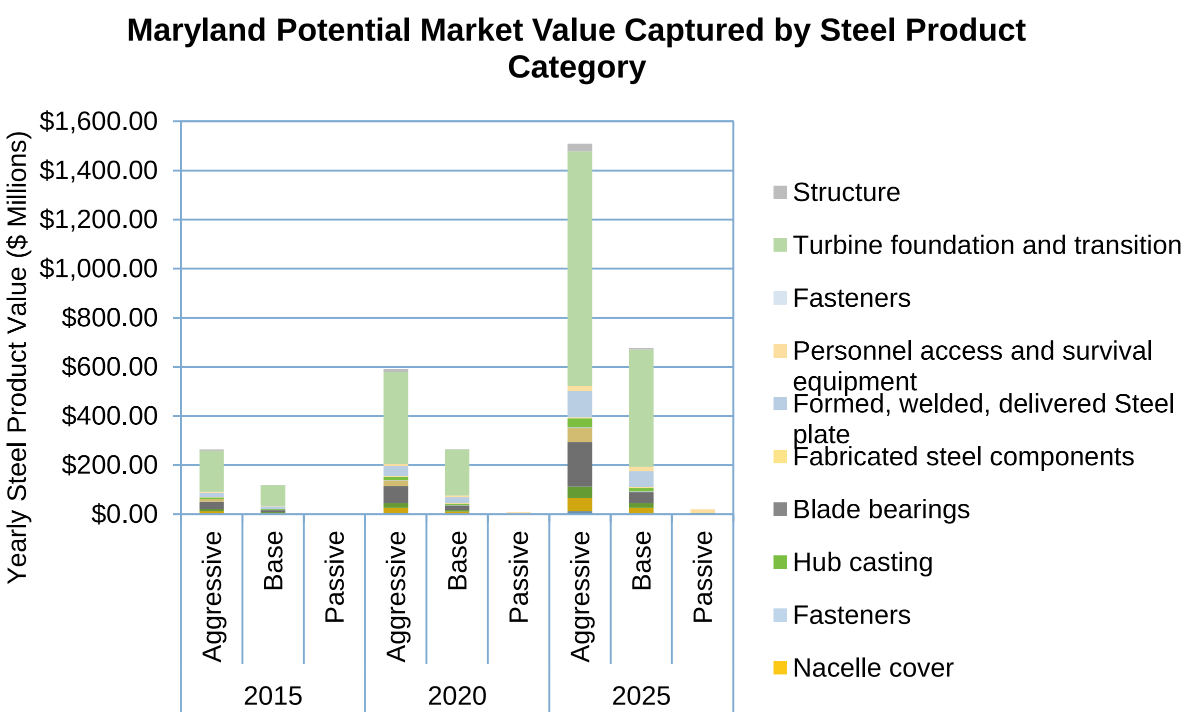
The chart below shows the annualized value of the opportunity for a Maryland steel cluster for each of the three scenarios.



The following chart shows Maryland's opportunity against the estimated total steel product value for offshore wind on the US East Coast. This illustrates that the aggressive scenario allows Maryland companies to capture 14% of the steel component market share, whereas the base model will reach 6% by 2025.



The following graph shows potential value for Maryland by each product category, scenario and end-year: 2015, 2020 and 2025.



Economic Development implications

Employment effects will vary depending on which type of product will be produced at the cluster site. The sample data below illustrates employment levels by different tower and foundations manufacturing plants.

Product type	Company	Employment
Steel foundation	WeserWind - Offshore Construction Georgsmarienhütte	500
Steel tower and foundation	AMBAU	450
Steel foundation	Cuxhaven Steel Construction - CSC	200
Foundation	STRABAG Offshore Wind	500
Steel tower and foundation	Siag Nordseewerke	720
Monopile steel foundation	Steelwind Nordenham (Dillinger Hütte) in Vorbereitung	300

Actions to Maximize Value Capture

In order to take advantage of this scenario, we recommend taking the following actions and engaging the following stakeholders:

Collaboration: Any investment in Maryland's infrastructure to support the offshore wind industry will require high levels of collaboration and engagement with key stakeholders. In addition to the previously-mentioned top-target firms, it is critical to establish relationships with union and labor leadership, such as the United Steelworkers, Dockworkers, Teamsters, and Maryland state higher education and technical school organizations. These stakeholders are key to supplying the skills and talent necessary to serve the employment needs of this industry.

Investment in infrastructure: Investing in capability to build the high value components of the offshore wind value chain is the most critical action for capturing the opportunity in offshore wind. As such, it is incumbent upon the state of Maryland to support the efforts of its private firms in their development of ventures and expansion of businesses, support development of partnerships between Maryland and outside companies, or to attract outside companies in order to capture this opportunity. Our discussion of cluster development around RG Steel receives our strongest recommendation: expand the casting, plate making, rolling and welding capabilities at Sparrows Point, along with the development of onshore assembly from the numerous wharves surrounding the area. Additionally, there is opportunity for the development of ship and barge-making capabilities in Maryland, which are specifically designed to service the offshore wind industry.

Integrated operations with RG Steel: As per our cluster discussion, RG Steel should be the anchor of any investment in offshore wind supply. RG Steel's capability to provide micro-runs in the ramp up to full production is a strong asset in developing an offshore wind steel production cluster, and its long-term capability to engage in foundry operations is a strong asset as well. In addition, Maryland has embedded machining and fabrication knowledge based on its industrial composition, which should be incorporated into development of the cluster.

Aggregation of operations at Sparrows Point: While Maryland has a handful of strong players in the steel fabrication industry, a significant number of smaller firms could positively support the growth of the industry. We propose the development of an industrial consortium or collaborative enabling the support of these firms at the consortium level. An active consortium could develop more buying power for its members through aggregated buying and economies of scope through closer ties by adjacent companies in the supply chain. This will increase business while decreasing the cost of material inputs.

Partner with European offshore wind companies: Knowledge and technology transfer from European offshore wind operations is vital to the long-term success of the US offshore wind industry. Maryland can put itself in an advantageous position by partnering with manufacturers such as Siemens or Vestas to build the necessary knowledge to create the premier offshore cluster location in the US. In addition, Maryland should engage the largest operators of European offshore wind farms and connect them with large East Coast utilities and utility groups, such as the Edison Electric Institute.

Transformational projects: Develop a high visibility transformational project that would attract public and institutional attention. For example, a multi-gigawatt project to provide energy to the DC Metro area or the development of a fully functional development and validation park offshore are clear messages to industry.

Standards: Maryland should engage early with standards committees and resident industries to gain early advancement and input into the technical specifications which are required for offshore wind material, specifically steel. It is in Maryland's best interest to make sure that the requirements are both fair to its industries as well as communicated early enough for its industries to adapt to best supply practices.

Appendices

Vessels - Jones Act

The Merchant Marine Act of 1920, commonly known as the Jones Act, requires vessels engaged in the transport of passengers or cargo between U.S. places to be built and flagged in the United States, and owned and crewed by U.S. citizens. Vessels with bottom-fixed foundations within the United States will be subject to the Jones Act, however, vessels which are used to transport turbine components from overseas to a U.S. staging port, are not subject to the Jones Act. Thus, cargo and delivery vessels may be owned/operated/flown under flags of non-US origin.

In Europe, offshore wind manufacturers and contractors prefer to use purpose-built vessels. However, these are not currently available in the US, nor are they expected to be available as the first offshore projects begin installation. The cost to construct these vessels range from $40-$80 Million for specialty-designed tug vessels, and $150-$250 Million for self-propelled vessels. There are non-optimal substitutes available for use in the US, though, such as jack-up vessels used in the oil-platform industry, but their use could take more installation time than custom-built vessels and thus could increase installation costs.

Currently there are no offshore wind energy purpose-built vessels available in the United States. Vessels which are compliant with the Jones Act but serve other offshore industries operating in the Gulf of Mexico could be used to construct the first-generation U.S. offshore wind farms. These vessels lack the efficient, optimized features found in wind turbine installation vessels: the ability to transport multiple turbine sets/components, the ability to rapidly jack up, pre-load the legs, erect the turbines, and jack down. In order to economically meet projected offshore wind demand in the U.S., a fleet of purpose-built, Jones-Act-compliant vessels will be required.

Offshore Wind Vessels

Import/Transport Vessels

Import vessels will only be subject to spatial requirements: length, beam and draft. Depending on the design of the wind turbine itself, the specifications necessary to transport or import disassembled components will can be up to 470’ length, 75’ beam, 32’ draft.

Low draft Barges

Low-draft barges are ideally suited to perform structure-to-shore pipeline and cabling investigations. However, high ocean currents cause instability, and they require the use of tugboats for power

Jack-up vessels

Jack-up rigs provide a stable working platform, however, expensive daily rates (e.g. up to $150K per day) and significant support requirements can reduce their cost-effectiveness. They are typically used for oilfield activities.

Offshore wind turbine foundations are usually installed by floating crane vessels or mobile jack-up units, the choice of which is dependent on water depth, crane capability, and vessel availability. When using a crane vessel, it must be capable of lifting hook heights greater than the height of the rotor-nacelle assembly of the turbine. Some of the lift capacities along with other equipment specifications are summarized below. In shallow waters, conventional mobile jack-up rigs are typical, whereas for deeper waters, the floating crane vessels are usually deployed.

Crane Requirements

The type of turbine can have a significant effect on the capabilities of available installation cranes. Depending on nameplate capacity, nacelles can weigh between 140 and 320 tons, and monopiles can weigh up to 500 tons.

Availability

Declining US shipyard activity has created a capacity issue in the U.S. due to regulatory restrictions such as the Jones Act. As the number of available yards decrease, the availability of yards able to meet these requirements also decreases. This is particularly acute on the US East Coast.

Specialty wind farm vessels have unique construction and servicing requirements. Construction demand over the last decade in the US has steadily increased in the US based on the aging of the existing fleet. A growing number of stricter regulations and replacement requirements have increased demand for new construction in recent years with the largest demand market currently being the tug and barge industry.

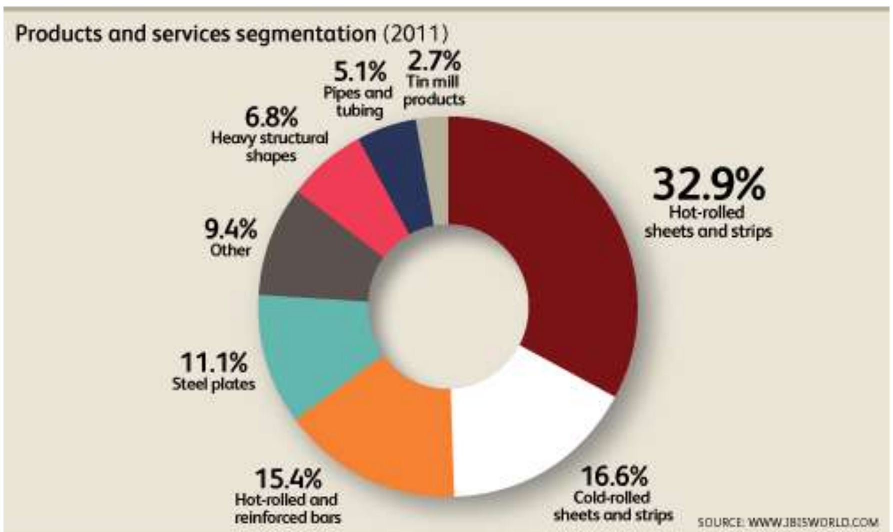
US Steel Production

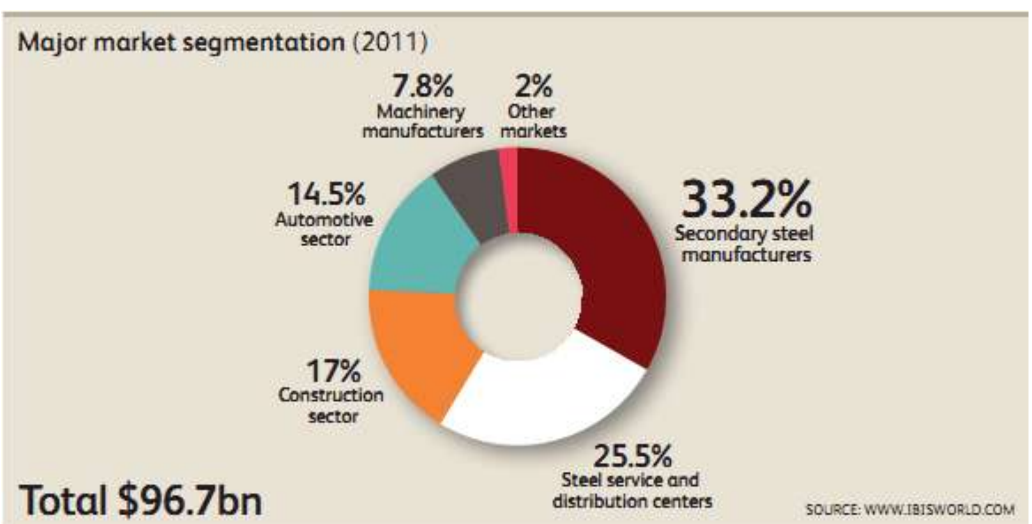
Competitors- RG Steel

While there are several integrated steel producers in the US, the only mill considered a threat to RG Steel setting up a cluster of offshore wind turbine supply facilities is Nucor. The other large mills are primarily focused on mid-west operations such as autos and other large industrial fabricators. Imported steel could also pose a threat, however this will be a function of global steel price arbitrage, logistics costs, quality conformity and macroeconomic trade policy in the form of tariffs and duties.

Market Dynamics

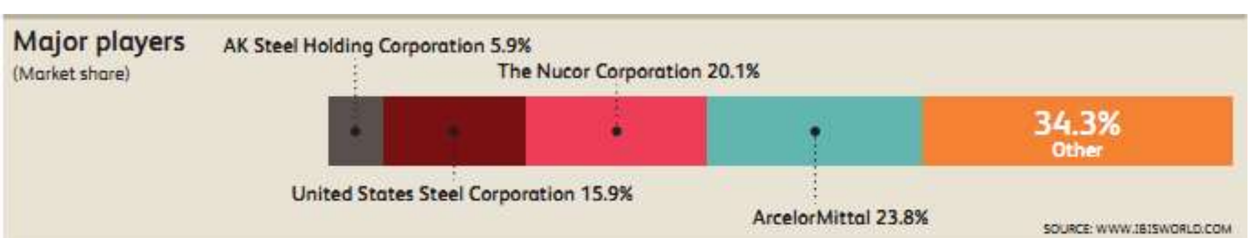
The total US steel market had a value of $96.7 Billion in 2011. It is expected to grow significantly in upcoming years as steel manufacturers shift their away from high volume, low margin products to more specialized, engineered, value-added products; such as wind turbine components. Sales volumes exceeded 80.5 million tons in 2010. ArcelorMIttal is currently the volume market leader, capturing 23.8%. For the offshore wind industry, the applicable products comprise the following proportion of steel production: steel plate (11.1%), heavy structural (6.8%).





Steel Production Concentration by Location

The Southeast and Mid-Atlantic are major producing regions, making up 19.6% and 16.4% of total raw steel production, respectively.



ArcelorMittal Steel USA

A subsidiary of ArcelorMittal S.A. in Luxembourg, ArcelorMittal Steel USA is the largest steel producer in the country. Its 18 US facilities consist of four integrated steelmaking plants, one basic oxygen furnace/compact strip mill, six electric arc furnace plants, five finishing plants and two coke-making operations. ArcelorMittal USA also owns interests in various joint ventures that support these facilities as well as numerous raw material, railroad and transportation assets. ArcelorMittal USA's main operations include integrated steel-making plants in Indiana, Illinois, Ohio and West Virginia. In May 2008, ArcelorMittal sold its Sparrows Point integrated steel mill in Baltimore, Maryland to Severstal North America. It has a diverse product portfolio and separates its operations into the following segments in the USA: flat carbon Americas, long carbon Americas and Europe, and steel solutions and services. Its flat carbon Americas segment represents about 25.0% of consolidated company revenue and corresponds to ArcelorMittal Steel USA as US operations primarily produce flat carbon products and the company's Americas segment is centralized in the United States. ArcelorMittal has long products operations on the Eastern Seaboard (rail, wire, rod), which are outside of the competency necessary to supply large portions of the offshore wind supply chain.

Nucor

Nucor currently supplies the onshore wind industry from its Mempis, TN works. With a production capability that exceeds 26 million tons, Nucor Corporation is one of the largest steel producers in the country. The company is headquartered in Charlotte, NC and operates and sells primarily within North America. Nucor utilized Electric Arc Furnace technology, using scrap steel as its primary input, which is then melted and reprocessed into several different steel products. Nucor is the largest steel recycler in the United States, having processed 17 million tons of scrap steel in 2010. Nucor operates a total of 23 mills in the United States, primarily in the Southeast and Great Lakes regions. Its products are highly diversified and have wide usage across various industries.

The sheet mills produce flat-rolled steel for automotive, appliance, pipe and tube, construction, and other industries. The company operates four sheet mills with a total capacity of approximately 10.8 million tons per year. It has applicable sheet operations on the Eastern Seaboard in Huger, SC.

The structural mills produce wide flange steel beams, pilings, and heavy structural steel products for fabricators, construction companies, manufacturers, and steel service centers. Current annual production capacity of the two structural mills is approximately 3.7 million tons.

Nucor operates two plate mills. The plate mills division produces plate for manufacturers of heavy equipment, rail cars, wind towers, bridges, ships, barges, and refinery tanks, among others. It also offers thinner gauges of coiled and cut-to-length plate used in the pipe and tube, pressure vessel, transportation, and construction industries. Current annual production capacity of the two plate mills is approximately 2.8 million tons. It has plate operations on the Eastern Seaboard at Cofield, NC.

With its embedded knowledge supplying the onshore wind industry and its various locations on the Eastern Seaboard, Nucor is viewed as the highest threat to RG Steel developing an offshore wind tower cluster at Sparrows Point.

Severstal

Severstal North America (SNA) is headquartered in Dearborn, MI and sold its Sparrows Point assets to New York-based Renco Group in April 2011, which subsequently became RG Steel. It is not considered a competitor locus or product-wise.

United States Steel

United States Steel is an integrated steel producer with major production operations in the United States, Canada and Central Europe and an annual raw steelmaking capability of 31.7 million tons (24.3 million in North America and 7.4 million in Central

Europe).US Steel has a large flat-rolled products segment which includes US Steel's North American integrated steel mills. The company manufactures a wide range of value-added steel sheet and tubular products for the automotive, appliance, container, industrial machinery, construction, and oil and gas industries. Using traditional blast furnaces, US Steel produces raw steel at five main sites in the United States: Gary, IN; Mon Valley, PA; Fairfield, AL; Great Lakes, MI; and Granite City, IL. In terms of relevance to the offshore wind turbine value chain, its closest steel processing works to the Eastern Seaboard are in Fairless, PA where they process cold-rolled sheet into galvanized sheet. Thus it is not considered a high threat to RG Steel.

AK Steel

AK Steel Holding Corporation is headquartered in Middletown, OH and operates major steelmaking facilities in Indiana, Kentucky, Ohio and Pennsylvania. AK Steel produces flat-rolled carbon, stainless and electrical steel products for automotive, appliance, construction and manufacturing markets, as well as standard pipe and tubular steel products. The company's operations consist of seven steel-making and finishing plants located in Indiana, Kentucky, Ohio and Pennsylvania that produce flat-rolled carbon steels, including premium-quality coated, cold-rolled and hot-rolled products, and specialty stainless and electrical steels that are sold in hot band, sheet and strip form. It's works are not near the Eastern Seaboard and thus is not considered competitive.

Foreign Imports

With several European steel suppliers already supplying their domestic offshore wind industries, the only barriers to entry for foreign steel products to be imported and formed to offshore wind turbine specification are: global steel price arbitrage, quality conformity and macroeconomic trade policy in the form of tariffs and duties.

About this study

Kinetik Partners conducted this independent study for the Maryland Energy Administration. The information and analysis presented on this document is based on public information and on Kinetik's experience in the global wind industry. Our team contacted and obtained selective data through telephone interviews, e-mail contact of industry participants and a comprehensive review of currently available secondary sources. This information has been used to build a proprietary models for the US wind energy sector.

The confidentiality of our clients' plans and data is critical. Kinetik rigorously applies processes to protect the confidentiality of all client information. Similarly we view our approaches and insights as proprietary. Therefore, we look to our clients to protect Kinetik's interests in our presentations, methodologies, and analytical techniques. Under no circumstances should this material be shared with any third party, including competitors, without the written consent of Kinetik.

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