U.S. Job Creation in Offshore Wind

A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind

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Final Report

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Table of Contents

List of Figures

List of Tables

Summary

The goal of the Roadmap Project for Multi-State Cooperation on Offshore Wind is to understand the economic benefits from the development of offshore wind farms off the U.S. Northeast coastline, from Maine to Maryland. It commissioned BVG Associates to conduct this study of job creation, drawing on its experience of offshore wind industrialization in Europe.

The analysis used two market scenarios for the Northeast: a low scenario in which 4GW is installed by 2030 and a high scenario in which 8GW is installed by 2030. The study considered 17 subelements of the offshore wind supply chain and concluded whether the jobs would be baseline, where there are no compelling reasons why the work would not be undertaken in the U.S., or additional, where the demand for jobs is less certain (high, medium, or low probability). In both scenarios, about 45% of jobs are baseline (see Figures S-1 and S-2). These jobs are related to the development of wind farms, the manufacture of substations, and the delivery of operations, maintenance, and service (OMS) activities.

In the low scenario, this translates to 160,000 baseline full-time equivalent (FTE) job years over the lifetime of the wind farms, with a peak of 8,300 FTE jobs in 2028 (see Figure S-1). In the high scenario, there would be a total of 320,000 baseline FTE job years, with a peak of 16,700 FTE jobs in 2028 (see Figure S-2).[1]

If additional jobs with a medium or high probability of being performed in the U.S. are performed there, a total of 195,000 FTE US job years are created in the low scenario over the lifetime of the wind farms, with a peak of 12,600 FTE jobs in 2028, including baseline jobs. For the high scenario, there would be 500,000 FTE job years, with a peak of 36,300 FTE jobs in 2028.

The reason for greater numbers in the high scenario is that the levels of deployment make it more likely that additional jobs will be created. For example, U.S. production of turbine blades and towers, foundations, and array cables becomes a high probability. The annual market of 960MW

[1] An FTE job year is the equivalent of one full-time worker employed for an entire year, two full-time workers employed for six months each, or any other combination that adds up to a full-time worker for an entire year. The 250,000 baseline FTE job years in the low scenario is equivalent to 25,000 workers each employed for 10 years.

in the late 2020s provides sufficient demand for investment in new manufacturing facilities to take place. This finding suggests significant economic development benefits from the U.S. having a robust pipeline of offshore wind projects.

Figure S-1. Total number of FTE jobs and the probability of securing these in the U.S. between 2020 and 2030 under the low scenario (4GW)[2]

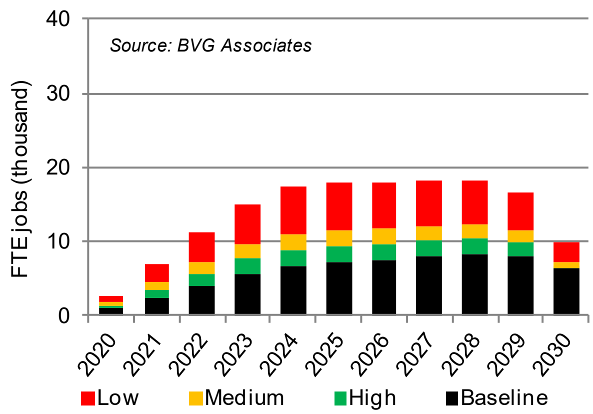
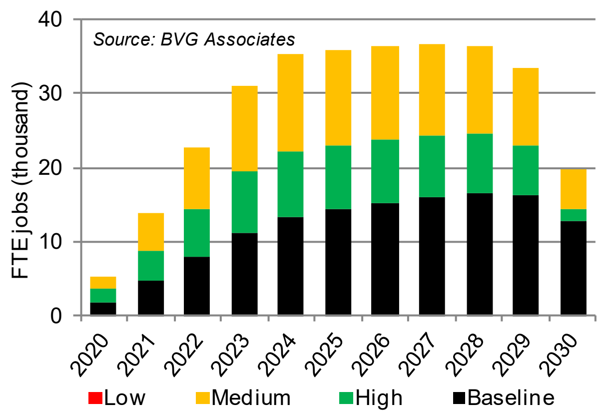


Figure S-2. Total number of FTE jobs and the probability of securing these in the U.S. between 2020 and 2030 under the high scenario (8GW)



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2 The number of FTE years supported declines toward the end of the decade because the study assumed labor savings as the supply chain matures and, more importantly, the study only considered wind farm capacity developed and installed up to 2030. If a pipeline of new project installation continues after 2030, there would be additional jobs before 2030 to prepare and additional jobs after 2030 to install and operate them.

These findings assume that investments leading to offshore wind jobs in the U.S. are made on purely commercial grounds. States and the federal government may offer a range of incentives for local investment because the economic benefits from job creation exceed the cost of the incentives. Were that to happen, then the outlook for U.S. jobs could be more favorable than the one presented here.

The study analyzed the specific occupations created in each of the 17 supply chain subelements using the Bureau of Labor Statistics' Standard Occupational Classification (SOC) system. Excluding the jobs created in general business services and equipment showed 75% of the FTE years created are spread between three major group occupational categories:

- Installation, repair, and maintenance
- Management
- Production

Broad group occupations were further analyzed. The main finding was a significant requirement for technician-level workers. These may be in:

- Production roles, particularly high-value manufacturing positions
- Installation and commissioning positions, vessel and offshore equipment operation, and commissioning and testing turbines, cables, and substations
- OMS roles, particularly turbine technicians

Although these technician roles are quite diverse, many initially will follow similar training paths. This means that skills development organizations in key states can establish their workforce training initiatives now in preparation of advancing local supply chains.

1 Introduction

The goal of the Roadmap Project for Multi-State Cooperation on Offshore Wind is to understand the economic benefits from the development of offshore wind farms off the coastline of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Jersey, New York, and Rhode Island.
It commissioned BVG Associates to conduct this study, drawing on its experience of offshore wind industrialization in Europe.

The analysis used two scenarios for the growth of offshore wind in waters off the U.S. Northeast coast: a low scenario in which 4GW of capacity is deployed by the end of 2030 and a high scenario in which 8GW of capacity is deployed by the end of 2030.

This report presents the total number of jobs created across the entire supply chain and splits that total into different types of occupations. Not all the jobs created in the offshore wind supply chain are equally likely to be captured in the U.S. Each scenario considered the probability that the jobs created would be U.S.-based.

This analysis assumed that investments leading to offshore wind job creation in the U.S. are made on purely commercial grounds. States may choose to offer incentives for local investment through a range of mechanisms. They could conclude that the economic benefits from job creation will exceed the cost of the incentives. Were this to happen, the outlook for U.S. offshore wind jobs could be even more favorable than the one presented here.

While the term job creation is used throughout, some of the offshore wind jobs could displace those from other power generation sectors.

2 Methodology

2.1 Economic Model

This analysis used an economic model that was developed in partnership with the University of the Highlands and Islands in Scotland. This model was developed because the conventional approach to assessing economic impacts of investments is insufficient for understanding the offshore wind sector. Conventional economic analyses rely on multipliers derived from government statistics covering established industrial sectors, such as those defined in the North American Industry Classification System (NAICS). Those multipliers are unsatisfactory for use with the offshore wind supply chain because the industry classifications do not map easily onto the offshore wind sector. The model derives bespoke multipliers based on the specific features of different parts of the offshore wind supply chain. It is informed by BVGA's extensive experience in the industry. Appendix A contains a more detailed explanation.

This report uses the following key inputs:

- A projection of future offshore wind capacity in the Northeast
- Modeled U.S. offshore wind costs, now and in the future, of development, construction, and operation activities based on an operating life of 25 years
- Anticipated U.S. offshore wind farm supply chain profit margins, salaries and other costs of employment

The report calculates the direct and indirect FTE years of employment (one FTE year is one full time job for one year), where:

- Direct FTE years are the jobs of those employed by the owners of the wind farm asset and their primary contractors
- Indirect FTE years are the jobs of those employed by suppliers and subsuppliers to the owners or their primary contractors

2.1.1 U.S. Offshore Wind Scenarios

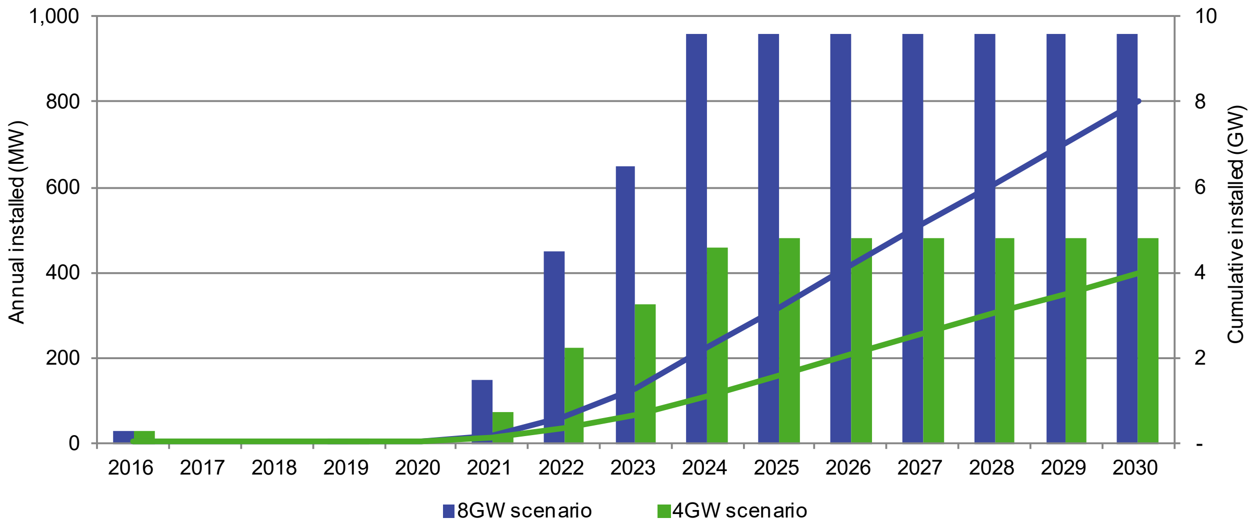
The analysis used two scenarios in agreement with the Multistate Offshore Wind Project partners for the new offshore wind capacity off the Northeast coast from Maine to Maryland (see Figure 1).

In the low scenario, annual installed capacity reaches 480MW in 2024 and continues at the same rate until 2030, with 4GW installed in total. In the high scenario, annual installed capacity reaches 960MW in 2024 and continues at the same rate until 2030 with 8GW installed in total.

A small amount of additional capacity may be built in states to the south of Maryland; however, it is not expected to have a significant impact on the development of the supply chain.

Although this forecast stops at 2030, the conclusions on the development of the U.S. supply chain assume that new capacity is installed at a similar rate until the mid-2030s at least. The jobs created from wind farms built after 2030 have not been modeled.

Figure 1. Forecast annual and cumulative offshore wind capacity in the Northeast U.S. under the low (4GW) and high (8GW) scenarios



2.1.2 U.S. Offshore Wind Costs

Costs are estimated at 2016 prices and based on a wind farm set for completion in 2022 using a U.S. supply chain. Cost data extends forward and backward from this point using expected offshore wind learning rates (equivalent to a 2% annual reduction in undiscounted expenditure). This recognizes that earlier costs are likely to be higher because the U.S. industry is relatively inexperienced, but later costs will be lower as companies gain more experience and benefit from industry innovations globally.

2.1.3 Profits, Salaries, and Costs of Employment

Data is included on profit margins, salaries, and other costs of employment from information published by individual states in equivalent sectors. The Bureau of Labor Statistics Standard Occupational Classification (SOC) system provided salary estimates closest to those of future workers in the offshore wind sector.

2.2 Scope of Analysis

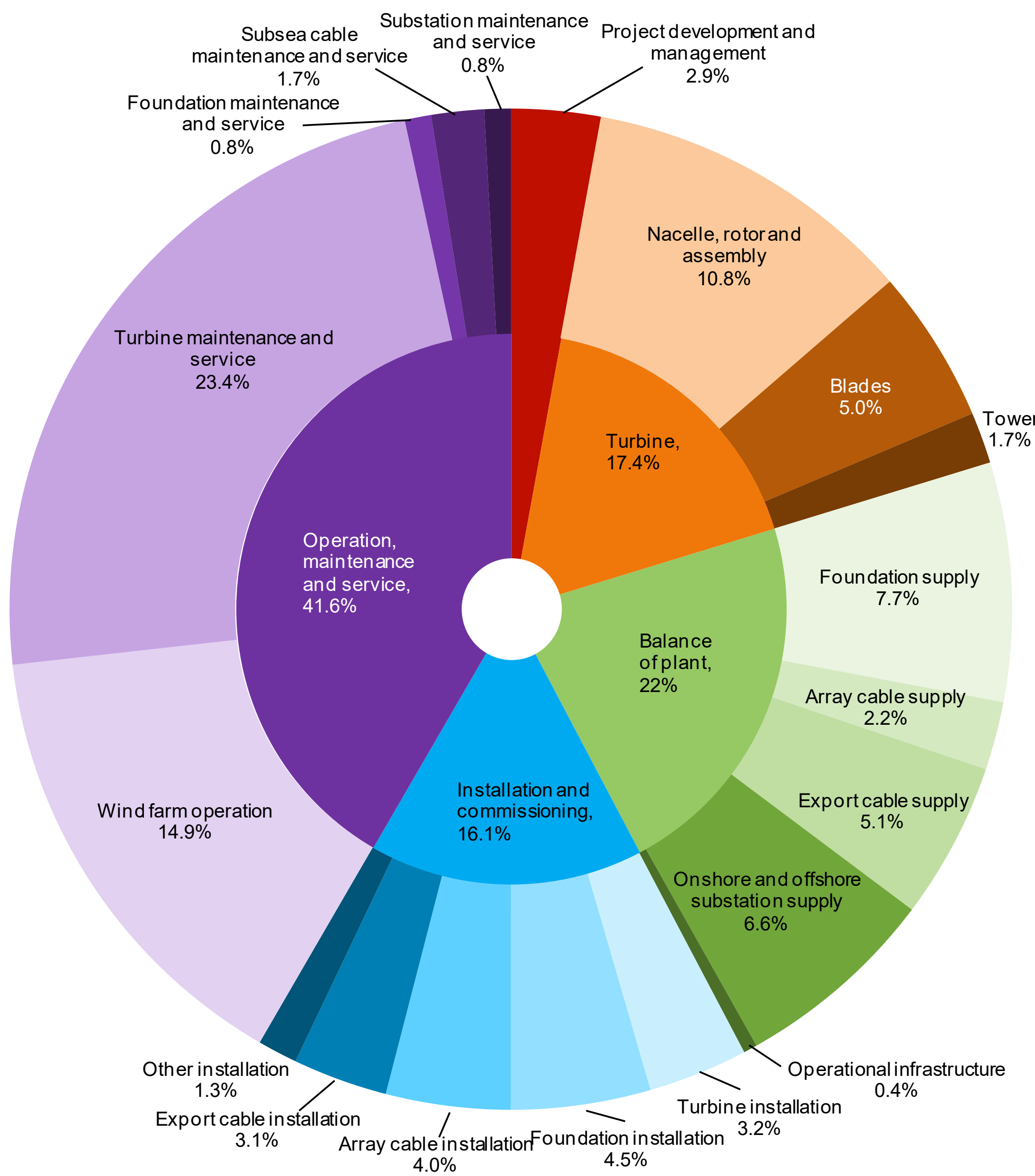
2.2.1 Supply Chain Elements

Analysis is based on the supply chain elements shown in Table 1. Figure 2 shows a breakdown of these element costs for a wind farm commissioned in 2022. Undiscounted costs, rather than the net present value, were used because these correlate more closely with the job creation associated with each supply chain element.

Table 1. Offshore wind supply chain elements and subelements

Phase	Element	Subelement
Capital expenditure (CAPEX)	Project development and management	Project development and management
	Turbine supply	Nacelle, rotor and assembly
		Blades
		Tower
	Balance of plant supply	Foundation
		Array cables
		Export cable
		Substation supply and operational infrastructure
	Installation and commissioning	Turbine
		Foundation
		Subsea cable
		Other installation
Operational expenditure (OPEX)	Wind farm operation	
	Turbine maintenance and service	
	Foundation maintenance and service	
	Subsea cable maintenance and service	
	Substation maintenance and service	

Figure 2. Breakdown of total undiscounted conventional offshore wind farm costs for a U.S. farm completed in 2022



2.2.2 Occupation Types

The report categorizes types of jobs that would be created using the Department of Labor's Standard Occupational Classification (SOC) system.[3] Federal statistical agencies use this data to classify workers into occupational categories to collect, calculate, or disseminate data. All workers are classified into one of 840 detailed occupations according to their professional definition. To facilitate classification, detailed occupations are combined to form 461 broad occupations, 97 minor groups, and 23 major groups.

The subelements listed in Table 1 have an estimated percentage of jobs in each relevant SOC code. The data was provided by established offshore wind developers and suppliers, based on their experience in Europe. Although there may be subtle differences between Europe and the U.S., the fundamental activities will be the same and these are unlikely to lead to significant variations in the SOC codes. Generic assumptions were applied where direct data was unavailable. For example, the range and number of jobs within steel fabrication or in high-value manufacturing are unlikely to differ significantly between different subelements and similar assumptions can be applied where appropriate.

All companies use generic services such as office supplies, utilities, travel, catering, cleaning, and office rental or maintenance. The offshore wind market will support some employment in these areas, but it was not possible to identify the specific job titles of those delivering these services. The study excluded the jobs created from investments in equipment and infrastructure, such as vessels and factories.

2.3 Approach

The study analyzed the following stages:

1. Research of the European offshore wind supply chain and classify occupations involved by SOC code. This was undertaken for each subelement of the supply chain.
2. Calculations of the total number of jobs created in the supply chain
3. Analysis of the likelihood that activity in a subelement would create jobs in the U.S. for each market scenario. Jobs were classified as being baseline and additional, whereby:
    - Baseline jobs are those where there are no compelling reasons why the work would not be undertaken in the U.S. These baseline jobs are not necessarily undertaken by U.S. nationals.
    - Additional jobs may be created in the U.S. by investments in new manufacturing and service facilities. These additional jobs were categorized as high, medium or low probability for each scenario.

[3] https://www.bls.gov/soc/

The total number of jobs (FTE years) was calculated by using the methodology described in Appendix A.

In analyzing the likelihood that a subelement will create jobs under each scenario, the study considered four main drivers:

- **Additional supply chain capacity**: the U.S. market may create new demand that cannot be met from existing factories
- **Benefits of local supply**: imported components or services from outside the U.S. may have significantly higher costs or risks
- **Local expertise**: U.S. companies may have world-class capability that is unlocked by the creation of a local market
- **Market structure**: conditions imposed on developers, such as lead times for delivery or local content, may support or hinder investment in local capacity

For simplicity, each subelement are treated as a whole, and all jobs associated with each subelement are treated as either baseline or additional. However, generalizing about large subelements can obscure what will be a more complex jobs picture. In reality, the U.S. is unlikely to secure 100% of the jobs from a subelement judged as baseline. On the other hand, the U.S. will likely secure some jobs even from a subelement judged as low probability. At this stage, it is appropriate to assume these variations will balance out.

3 Total Offshore Wind Jobs

For each market scenario, the study presents the total number (inside or outside of the U.S.) of FTE years created by the wind farms constructed by the end of 2030 until the end of their lives in 2056 (assuming a 25-year life). The graphs in this section show the FTE years created for 2020–2030.

3.1 Low Scenario

In the low (4GW) scenario, offshore wind farms commissioned in the U.S. between 2016 and the end of 2030 will create 248,000 FTE years in the supply chain between 2016 and 2056. Wind farms built in this period will continue to support a significant number of jobs during the 25 years of operation. Figure 3 shows the FTE years created annually between 2020 and 2030. Table 2 shows the number of FTE years supported annually between 2020 and 2030 and the total FTE years created between 2016 and 2056.

The number of jobs declines after 2028. Because the scenario includes no new capacity after 2030, no jobs are created in 2029 and 2030 for wind farms built after 2030. In reality, the prospects for U.S. offshore wind are good, so development should continue after 2030, sustaining the employment created in all supply chain subelements. There is also a general decline in the number of jobs created as the industry succeeds in reducing costs.

The jobs in turbine supply, balance of plant, and installation are created over a two- to three-year period up to the end of construction. Jobs in development and project management are created in a five- to seven-year period up to the end of construction. Jobs in OMS are created first in the final year of construction and sustained for 25 years.

3.2 High Scenario

In the high (8GW) scenario, offshore wind farms commissioned in the U.S. between 2016 and the end of 2030 will create 500,000 FTE years in the supply chain between 2016 and 2056. Wind farms built in this period will continue to support a significant number of jobs during the 25 years of operation. Figure 4 shows the FTE years created annually between 2020 and 2030.

Table 3 shows the number of FTE years supported annually between 2020 and 2030 and the total FTE years created between 2016 and 2056.

Figure 3. Total available direct and indirect FTE years created annually between 2020 and 2030 by supply chain element in the low scenario (4GW)

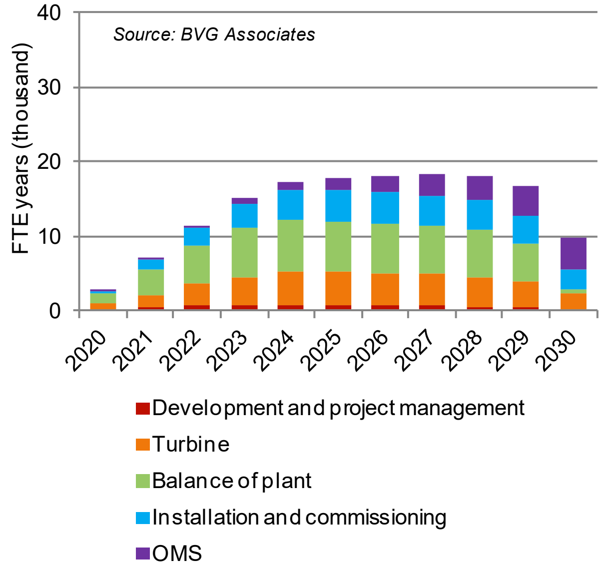


Figure 4. Total available direct and indirect FTE years created annually between 2020 and 2030 by supply chain element in the high scenario (8GW)

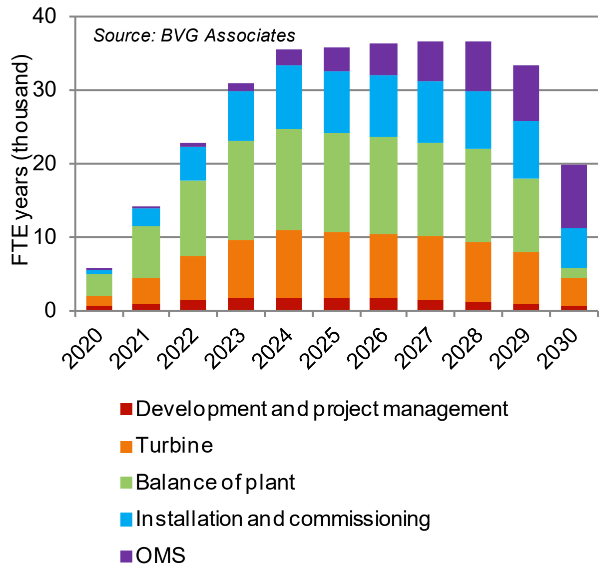


Table 2. Total available direct and indirect FTE years created by supply chain subelement in the low scenario (4GW)

Element	Subelement	FTE year employment 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2016-2056
Project development and management		310	490	660	770	840	840	780	690	600	430	230	6,980
Turbine supply	Nacelle, rotor and assembly	460	1170	1980	2580	3000	3010	2950	2890	2670	2350	1380	24,700
	Blades	170	430	720	940	1100	1100	1080	1060	980	860	510	9,000
	Tower	40	140	240	330	370	370	370	360	350	340	140	3,000
Balance of plant	Foundation	500	1150	1680	2170	2260	2220	2180	2130	2090	1650	210	18,400
	Array cables	140	320	460	590	620	610	600	580	570	450	60	5,000
	Export cable	360	830	1200	1550	1620	1590	1560	1530	1500	1180	150	13,200
	Substation supply and operational infrastructure	510	1190	1730	2230	2320	2290	2240	2200	2150	1700	210	18,900
Installation and commissioning	Turbine	30	160	340	470	590	600	590	580	560	550	380	4,900
	Foundation	60	330	690	970	1210	1220	1200	1170	1150	1130	780	10,000
	Subsea cable	100	530	1110	1550	1940	1960	1920	1890	1850	1810	1250	16,000
	Other installation	20	120	250	360	440	450	440	430	420	410	290	3,700
Operation, maintenance and service	Wind farm operation	0	20	70	170	300	460	610	770	920	1060	1210	32,000
	Turbine maintenance and service	10	40	160	390	690	1060	1420	1780	2130	2470	2800	74,200
	Foundation maintenance and service	0	0	10	10	20	30	50	60	70	80	90	2,400
	Subsea cable maintenance and service	0	0	10	20	40	60	80	100	120	140	160	4,300
	Substation maintenance and service	0	0	0	10	20	30	40	50	50	60	70	1,900
Total		2,710	6,920	11,310	15,110	17,380	17,900	18,110	18,270	18,180	16,670	9,920	248,580

Table 3. Total available direct and indirect FTE years created by supply chain subelement in the high scenario (8GW)

Element	Subelement	FTE year employment										
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2016-2056
Project development and management		630	980	1340	1570	1710	1670	1560	1380	1200	870	470	14,010
Turbine supply	**Nacelle, rotor and assembly**	920	2360	3980	5250	6140	6020	5900	5780	5340	4690	2760	49,580
	Blades	340	860	1460	1920	2250	2210	2160	2120	1960	1720	1010	18,170
	Tower	80	280	470	680	760	750	730	720	700	690	270	6,140
Balance of plant	**Foundation**	990	2300	3400	4470	4530	4440	4350	4270	4180	3290	410	36,860
	Array cables	270	630	930	1230	1240	1220	1190	1170	1150	900	110	10,110
	Export cable	710	1650	2440	3210	3250	3190	3120	3060	3000	2360	290	26,440
	Substation supply and operational infrastructure	1020	2370	3500	4610	4670	4580	4480	4400	4310	3390	420	37,980
Installation and commissioning	**Turbine**	60	320	680	970	1220	1200	1170	1150	1130	1110	760	9,790
	Foundation	130	660	1380	1970	2500	2450	2400	2350	2300	2260	1560	19,980
	Subsea cable	200	1060	2220	3160	4010	3930	3850	3770	3690	3620	2500	32,060
	Other installation	50	240	510	720	920	900	880	860	850	830	570	7,330
Operation, maintenance and service	**Wind farm operations**	0	30	140	330	600	920	1240	1540	1840	2140	2430	64,290
	Turbine maintenance and service	10	70	320	760	1390	2140	2860	3580	4270	4960	5630	149,050
	Foundation maintenance and service	0	0	10	20	50	70	90	120	140	160	180	4,890
	Subsea cable maintenance and service	0	0	20	40	80	120	160	200	240	280	320	8,540
	Substation maintenance and service	0	0	10	20	40	60	70	90	110	130	150	3,850
Total		5,410	13,810	22,810	30,930	35,360	35,870	36,210	36,560	36,410	33,400	19,840	499,070

4 U.S. Offshore Wind Jobs

This section considers which of the supply chain subelements are likely to lead to the creation of jobs in the U.S. as well as the factors that will determine which jobs are created and how this changes in the low and high market scenario. The conclusions are summarized in Table 4 and discussed in further sections.

Table 4. Assessment of the probability that of supply chain subelements creating U.S. jobs

Subelement	Global supply chain capacity	Logistic benefits of local supply	U.S. expertise	Market structure barriers	Probability of additional job creation	
					Low scenario	**High scenario**
Project management and development	Adequate	High	Medium	Low	Baseline	Baseline
Nacelle, rotor and assembly	Inadequate by mid-2020s	Medium	High	Low	Low	Medium
Blades	Inadequate by mid-2020s	High	High	Low	Medium	High
Tower	Inadequate by mid-2020s	High	High	High	Medium	High
Foundation supply	Inadequate by mid-2020s	High	Low	High	High	High
Array cables supply	Remain adequate	Medium	High	Medium	Medium	High
Export cable supply	Inadequate by mid-2020s	Medium	Low	High	Low	Medium
Substation supply and operational infrastructure	Remain adequate	High	Medium	Low	Baseline	Baseline
Foundation installation	Remain adequate	Medium	Low	High	Low	Medium
Turbine installation	Remain adequate	Medium	Low	High	Low	Medium
Array cable installation	Remain adequate	Medium	High	Low	Baseline	Baseline
Export cable installation	Remain adequate	Medium	Medium	Low	Baseline	Baseline

Table 4 continued

Subelement	Global supply chain capacity	Logistic benefits of local supply	U.S. expertise	Market structure barriers	Probability of additional job creation	
					Low scenario	**High scenario**
Other installation	Remain adequate	Medium	Low	Low	Baseline	Baseline
Wind farm operation	Remain adequate	High	High	Low	**Baseline**	**Baseline**
Turbine maintenance and service	Remain adequate	High	Medium	Low	**Baseline**	**Baseline**
Foundation maintenance and service	Remain adequate	High	High	Low	**Baseline**	**Baseline**
Subsea cable maintenance and service	Remain adequate	High	High	Low	**Baseline**	**Baseline**
Substation maintenance and service	Remain adequate	High	Medium	Low	**Baseline**	**Baseline**

4.1 Project management and development

Project development is generally undertaken in the home market and developers are likely to draw on consultancy skills from U.S. companies that have been active in the European market or are able to adapt quickly. There should, therefore, be no shortage of individuals in the U.S. available to do the work. Survey work will benefit from contractors with knowledge of the local environment and many U.S. companies will already be active in other offshore sectors requiring similar skills.

Conclusion

Project development and management will provide baseline jobs for the U.S., consistent for both market scenarios.

4.2 Turbine Supply

4.2.1 Nacelle, Hub, and Assembly

There should be sufficient capacity in European factories to export to a single 400-500MW U.S. project annually until the mid-2020s. For nacelles, assembly is ideally close to the wind farm, but it is more important for the turbine manufacturer to remain close to its major suppliers (currently in Europe) to mitigate supply chain risk. For this reason, nacelle and hub component manufacture and assembly need to be considered together.

There is widespread experience in nacelle and hub component manufacture and assembly in the U.S. from the onshore wind sector, although this is concentrated in other regions away from the Northeast coast. Turbine manufacturers typically get an early sight of the market and plan long-term to meet market demand.

Conclusion

In the low market scenario, there is a low probability the U.S. will secure nacelle, hub, and assembly jobs. A turbine manufacturer would need an annual offshore pipeline of at least 500MW. The low market scenario creates an annual market of 560MW after 2024 and it is unlikely a single manufacturer would expect a 90% market share.

In the high market scenario, there is a medium chance that the U.S. will secure nacelle and hub components and assembly. The market size may not support more than one U.S. investment and the proportion of assembled nacelles used for U.S. projects is likely to depend on the market share of the leading supplier.

4.2.2 Blades

There should be sufficient capacity in European factories to export to a single 400-500MW U.S. project annually until the mid-2020s. Transport and handling of blades is costly and there are few supply chain interfaces, which makes local supply beneficial.

The U.S. has established blade manufacturing skills, although this is concentrated in other regions away from the Northeast coast. Blades are generally manufactured in-house by turbine manufacturers, which allows for an early sight of the market and long-term planning to meet expected market demand.

Conclusion

In the low market scenario, there is a medium probability the U.S. will secure blade manufacturing jobs. A business case for investment may need to be built around a facility supplying both onshore and offshore sectors.

In the high market scenario, an investment in a U.S. blade manufacturing facility is a high probability. Transport from Europe is expensive and there is an existing U.S. composites supply chain.

4.3 Tower

There should be sufficient capacity in European and Asian factories to export to a single 400-500MW U.S. project annually until the mid-2020s. Transport and handling of towers is costly and there are few supply chain interfaces. Therefore, there is a strong benefit of local supply provided there is sufficient demand.

The U.S. has established tower manufacturing skills, although these are not necessarily in locations suitable for offshore wind tower manufacture. Towers are usually manufactured by third parties and a barrier to investment is the low profit margins in manufacturing. Investors have typically looked to amortize their investments over two years and demanded significant market certainty from turbine manufacturers.

Conclusion

In the low market scenario, there is a medium probability of U.S. jobs from tower manufacture. A U.S. supplier of towers would most likely need to capture a majority of the U.S. (or domestic) market to make an investment attractive.

An investment in a U.S. tower manufacturing facility is a high probability under the high market scenario. The market size may not support more than one U.S. investment and the proportion of U.S.-made towers used for projects will depend on the market share of the leading supplier. A supplier may need framework agreements with more than one turbine manufacture to secure investment.

4.4 Balance of Plant Supply

4.4.1 Foundation Supply

There will be sufficient capacity in European and Asian factories to export to a single 400-500MW U.S. project annually until the mid-2020s. Transport and handling of foundations is costly and there are few supply chain interfaces. The most important factor, however, is supply chain risk. Jacket foundations and the transition pieces for monopiles have a high labor cost with theoretical benefits from importing from low-cost Asian countries. Any delays or quality issues may have severe consequences and U.S. supply is likely to be a means of mitigating this risk; therefore, there is a strong benefit of local supply.

The U.S. has the infrastructure for manufacturing offshore structures in offshore oil and gas and shipbuilding. A unique requirement for offshore wind is the high number of structures needed for a project. This means there is ideally a significant investment in automated manufacturing lines and a cultural shift for companies used to supplying bespoke products.

Foundations may be sourced directly by the developer or by an EPCI (engineer, procure, construct, install) contractor. As detailed foundation design can only take place once a turbine is selected, investment in a production facility is likely required well in advance of any order. Foundation manufacturers have not typically been able to negotiate long-term agreements with their customers. Investment is, therefore, high risk stalling several planned investments in Europe.

Conclusion

Much depends on the appetite of suppliers from other sectors seeking to enter the offshore wind supply chain. Although there are U.S. fabrication yards, without investment, companies may find they are unable to match the prices of established offshore wind suppliers. However, foundation supply provides a high probability for additional U.S. jobs in both market scenarios.

4.4.2 Array Cables Supply

There should be sufficient capacity in factories in Europe and Asia to meet the demands of the industry until 2030. Cable transport and storage is costly because of the need for specialist vessels and equipment. The offshore wind industry has not stimulated significant investment in factories for new markets, mainly because of the high CAPEX and long lead time for new factories. Array cables are typically supplied from factories that also meet demand for oil and gas power cables and umbilicals. The U.S. has companies with the capability to make the transition.

Array cables are typically seen as commodity items by developers and the procurement process is often later than for other major components. With long lead times for new cable manufacturing lines or factories, manufacturers have typically been cautious about making investments at new sites to meet demand from the offshore wind industry.

Conclusion

Although U.S. companies have the capability, the creation of additional offshore wind jobs will depend on the appetite of U.S. manufacturers to make the necessary investments to enter the market. In the low scenario, this is a medium probability because U.S. manufacturers and investors may not view the market large enough to make investments. In the high scenario, there is high probability.

4.4.3 Export Cable Supply

Export cables are typically AC and rated between 132kV and 220kV. Subsea cables with these ratings are typically only used for offshore wind farms and high capacity interconnectors. Supply chain capacity has long been an area of concern for offshore wind developers and the growth of the U.S. market in both scenarios will create additional strain on supply.

Cable transport is costly because specialist cable vessels are needed, creating a significant logistical benefit of local supply. Current production facilities were, in most cases, built for large interconnector projects and are mostly in northern Europe where there are numerous links between northern European countries and their islands. At the same time, suppliers have been cautious about investing in new locations because of the risk of diluting their technical expertise.

There are no U.S. suppliers of high-voltage subsea cables. Any future capability is most likely to come from inward investment by an existing supplier, potentially forming a joint venture with a U.S. company. Building new factories has a long lead time and single offshore wind contracts do not existing manufacturing sites.

Conclusion

In the low market scenario, job creation from export cable supply is a low probability because of suppliers' caution in investing at new locations. In the high scenario, there is a medium probability because the increased U.S. market size means global supply is likely to become constrained and the U.S. becomes a logical place to extend suppliers' global manufacturing footprint.

4.4.4 Substation Supply and Operational Infrastructure

Globally, there is an overcapacity in terms of fabrication yards due to low demand of oil and gas platforms. Electrical equipment manufacturers can scale up production to meet demand relatively easily. It is likely to be too costly to import substation platforms and unnecessary given the capability of U.S. fabrication yards to produce oil and gas structures.

Conclusion

The jobs created can be considered as baseline in both scenarios because the skills and infrastructure needed are already in place in the U.S. to meet demand from the power, construction, and offshore oil and gas sectors. Substations are generally bespoke designs and the supply chain does not face the challenges of volume production faced in other areas of the supply chain.

4.5 Installation and Commissioning

4.5.1 Foundation Installation

Foundation installation uses large specialist vessels, most built in Asia. Although the Block Island wind farm used a Jones Act-compliant heavy lift vessel, this vessel is unlikely to be a cost-effective option for large-scale commercial projects, and we do not believe that the US has other vessels that are significantly more suitable.

A practical option is to use a feeder arrangement using a non-U.S. heavy lift vessel. This strategy has been widely used in Europe because the feeder is a low-cost vessel and many will be Jones Act compliant. CESA commissioned Gusto MSC to explore the viability of building a Jones Act-compliant jack-up installation vessel. It concluded that a Jones Act compliant vessel could be built with a 3.5-4GW pipeline. As the case is based on installation of both foundations and turbines, it may be weakened if there is a low-cost feeder option for turbine installation.

Conclusion

In the low market scenario, there is a low probability of additional U.S. jobs from foundation installation. Although a 4GW pipeline is sufficient for an investment, it is unlikely that an investor would get a clear view of this pipeline when making a financial commitment to the new vessel.

In the high market scenario, there is a medium probability of U.S. jobs. The pipeline is sufficient to build a Jones Act-compliant vessel, but investors and developers are likely to still consider feeder strategies to mitigate the risk that the Jones Act-compliant vessel is available.

4.5.2 Array and Export Cable Installation

Cable vessels are widely available in the global market, though many are not optimal for offshore wind work. Jones Act-compliant cables vessels are available both for the oil and gas and telecoms markets. Given expected low demand in the oil and gas sector, sufficient capacity is likely.

Conclusion

Cable installation jobs have been judged as baseline in both scenarios because the U.S. has an adequate cable vessel fleet. The transition from other sectors will not be straightforward because of the large number of complex operations involved in the cable pull-in and termination. In the early stages of the U.S. industry, therefore, contractors will benefit from input from European experience.

4.5.3 Turbine Installation

There are currently no Jones Act-compliant vessels suitable for installing turbines. Using a feeder vessel is an option, although this would be more expensive than a foundation feeder because it needs to be a jack-up with similar operating capabilities to the main installation vessel.

Conclusion

The conclusions for turbine installation jobs are the same as for foundation installation. In the low scenario, U.S. jobs are low probability and medium probability for the high scenario. The case for the Jones Act-compliant vessel described in the Gusto MSC report is based on it installing both turbines and foundations. It may be weakened if there is a low-cost feeder option for foundation installation.

4.5.4 Other Installations

Other installation involves offshore and onshore substations and the onshore export cable. Offshore substation installation is typically undertaken with a single offshore lift from a barge using a sheerleg or semisubmersible heavy lift vessel with a crane capacity of 3,000 tons or greater. If such a vessel is not available for a U.S. project, solutions can be developed for available vessels. In theory, a non-U.S. heavy vessel could be used without breaching the Jones Act, but the mobilization costs are likely to make this uneconomic.

Conclusion

The onshore substation and onshore cable installation will draw on a widely available skills base in the U.S. that supports the power and civil construction sectors. There would be no rational basis for sourcing this work outside the U.S. In both scenarios, other installation creates baseline jobs.

4.6 Operation, Maintenance, and Service

4.6.1 Wind Farm Operation

Wind farm operations covers the running a wind farm, such as asset management and procurement, and the provision of quayside infrastructure and equipment (including vessels). Most administrative functions are provided by a dedicated operating company with some services provided by one of its owners. Most of this work is undertaken locally at the operations base. Developers with overseas headquarters such as DONG Energy and Iberdrola may initially provide some of these services from their European teams, but they should be considered a source of baseline jobs in the longer term.

Conclusion

By necessity, infrastructure and equipment must be operated locally to ensure U.S. jobs in wind farm operations are baseline in both scenarios.

4.6.2 Turbine Maintenance and Service

Turbine manufacturers typically negotiate a five-year service agreement with the wind farm owner. Most of the jobs are created locally for day-to-day service tasks. Additional labor will be brought in for regular turbine maintenance work; but, in a mature U.S. offshore wind industry, this will be undertaken by technicians.

Conclusion

In the early stages of the U.S. industry, spare parts and consumables are likely imported. In the longer term, U.S. jobs could be created in these areas if there is investment in manufacturing facilities.

4.6.3 Foundation Maintenance and Service

Foundations are sold without any service agreement. Wind farm owners will undertake periodic assessments of the foundations structural integrity and the development of scour.

Conclusion

Although these services do not need to be provided by companies local to the wind farm, it is highly likely they will be provided by U.S. companies with a background in the offshore oil and gas industries.

4.6.4 Subsea Cable Maintenance and Service

Cable maintenance and service involves monitoring cable routes to ensure cables remain buried—an exposed cable is subject to significant mechanical loads from wave or tidal action and at greater risk of damage from fishing.

For an array cable failure, the defective cable is generally replaced, but export cables are repaired. Both tasks are likely to use a U.S. supply chain. If a failed export cable is under warranty, the manufacturer will generally take labor from its manufacturing plant to oversee the work. Otherwise, cable replacement will use the same supply chain as subsea cable installation.

Conclusion

These skills are likely to be provided from the U.S. and are baseline in both scenarios.

4.6.5 Substation Maintenance and Service

Wind farm owners typically agree on a service contract with the electrical supplier.

Conclusion

Suppliers already operate service divisions in the U.S. and it is likely these will be used to deliver the service contract.

4.7 Summary of U.S. Job Creation

Figures 5 and 6 show the number of FTE years that are baseline and low, medium, and high probability under the low and high market scenarios, respectively. They show that approximately 45% of FTE years are baseline in each case between 2027 and 2029. However, during the lifetime of the wind farms, the figure is 65%, reflecting the major contribution of jobs in operations, maintenance, and service after 2030. In the low scenario, the annual run rate of 560MW in the late 2020s is insufficient to create a business case for new offshore wind investment in many cases, and about 30% of FTE years are low probability U.S. jobs. In the high scenario, there are no low probability U.S. jobs because investment conditions will be more favorable. Tables 5 and 6 show the number of jobs annually that are baseline and high, medium, and low probability under the low and high scenarios, respectively. Table 7 shows the total number of jobs for the low and high scenarios for each element and subelement and which are baseline and high, medium, and low probability.

Figure 5. Total number of FTE years and the probability of securing these in the U.S. between 2020 and 2030 under the low scenario (4GW)

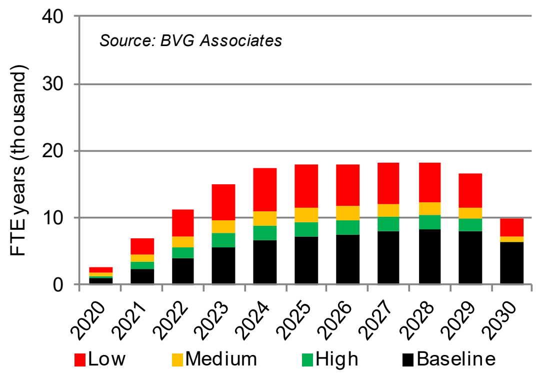


Figure 6. Total number of FTE years and the probability of securing these in the U.S. between 2020 and 2030 under the high scenario (8GW)

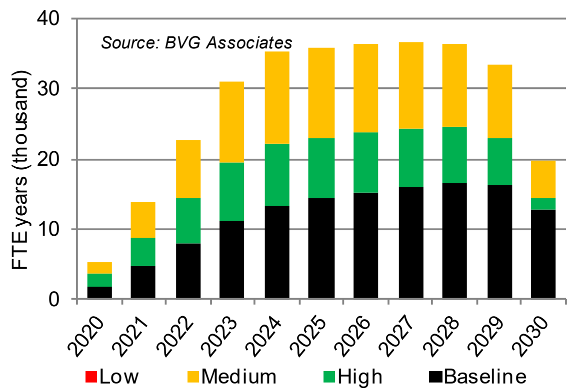


Table 5. Total number of FTE years in the U.S. and the number that are baseline and high, medium, and low probability in the low scenario (4 GW)

	FTE year employment											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2016-2056
Baseline	960	2,390	4,010	5,510	6,630	7,170	7,590	7,950	8,310	8,170	6,320	160,400
High probability	500	1,150	1,680	2,170	2,260	2,220	2,180	2,130	2,090	1,650	210	18,360
Medium probability	340	880	1,420	1,870	2,090	2,090	2,040	2,000	1,900	1,660	700	17,140
Low probability	910	2,490	4,210	5,570	6,420	6,430	6,300	6,170	5,890	5,210	2,690	52,690
Total	2,710	6,910	11,320	15,120	17,400	17,910	18,110	18,250	18,190	16,690	9,920	248,590
Percentage baseline	35%	35%	35%	36%	38%	40%	42%	44%	46%	49%	64%	65%

Table 6. Total number of FTE years in the U.S. and the number that are baseline and high, medium, and low probability in the high scenario (8 GW)

	FTE year employment											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2016-2056
Baseline	1,920	4,770	8,060	11,240	13,460	14,380	15,210	15,940	16,660	16,380	12,670	322,010
High probability	1,680	4,080	6,260	8,300	8,790	8,610	8,440	8,270	7,990	6,600	1,810	71,280
Medium probability	1,810	5,000	8,480	11,390	13,110	12,850	12,590	12,340	11,770	10,420	5,380	105,790
Low probability	-	-	-	-	-	-	-	-	-	-	-	0
Total	5,410	13,850	22,800	30,930	35,360	35,840	36,240	36,550	36,420	33,400	19,860	499,080
Percentage baseline	35%	34%	35%	36%	38%	40%	42%	44%	46%	49%	64%	65%

Table 7. Total number of FTE years for each supply chain element and subelement under the low and high scenario categorized as baseline ■, high probability ■, medium probability ■, and low probability ■

Element	Subelement	FTE years 2016-2056	
		Low scenario (4 GW)	High scenario (8GW)
Project development and management		6,980	14,010
Turbine supply	Nacelle, rotor and assembly	24,700	49,580
	Blades	9,000	18,170
	Tower	3,000	6,140
Balance of plant	Foundation	18,400	36,860
	Array cables	5,000	10,110
	Export cable	13,200	26,440
	Substation supply and operational infrastructure	18,900	37,980
Installation and commissioning	Turbine	4,900	9,790
	Foundation	10,000	19,980
	Subsea cable	16,000	32,060
	Other installation	3,700	7,330
Operation, maintenance and service	Wind farm operation	32,000	64,290
	Turbine maintenance and service	74,200	149,050
	Foundation maintenance and service	2,400	4,890
	Subsea cable maintenance and service	4,300	8,540
	Substation maintenance and service	1,900	3,850
Total		248,580	499,070

5 Offshore Wind Occupations

This section shows the analysis results into the types of occupations supported throughout the lifetime of an offshore wind farm and the relative numbers in each occupation supported by the U.S. pipeline. There is a breakdown of the total lifetime occupation by SOC major group category and for each supply chain element by major group category. These breakdowns do not vary by market scenario because this does not affect the occupations needed to undertake the work.

All companies procure a range of general services, including office supplies, utilities, transport, and business consultancy work. The breadth of these activities makes it difficult to develop a robust assessment, but are included in the qualitative analysis of FTE years in section 5. The pie charts in this section show the top 12 major group categories and then grouped all remaining activity as other.

5.1 Total Occupations

Figure 7 shows occupations by major group category involved in developing, constructing, and operating an offshore wind farm. Two-thirds of the jobs created are in installation, maintenance, and production. Many of these are technician-level positions. There are fewer engineering-level occupations because those tend to be at a more senior level and smaller in number. Management, business operation, and administration occupations feature strongly because they are needed in all parts of the supply chain.

Figure 8 shows the baseline job offshore wind occupations by SOC major group category. The figures are similar to those in Figure 7, but with slightly fewer installation, maintenance, and repair occupations because they exclude additional manufacturing and installation jobs. Appendix B includes a table with the occupations identified in the study with the numbers created for each scenario.

Figure 7. Total offshore wind occupations by Standard Occupational Classification major group category

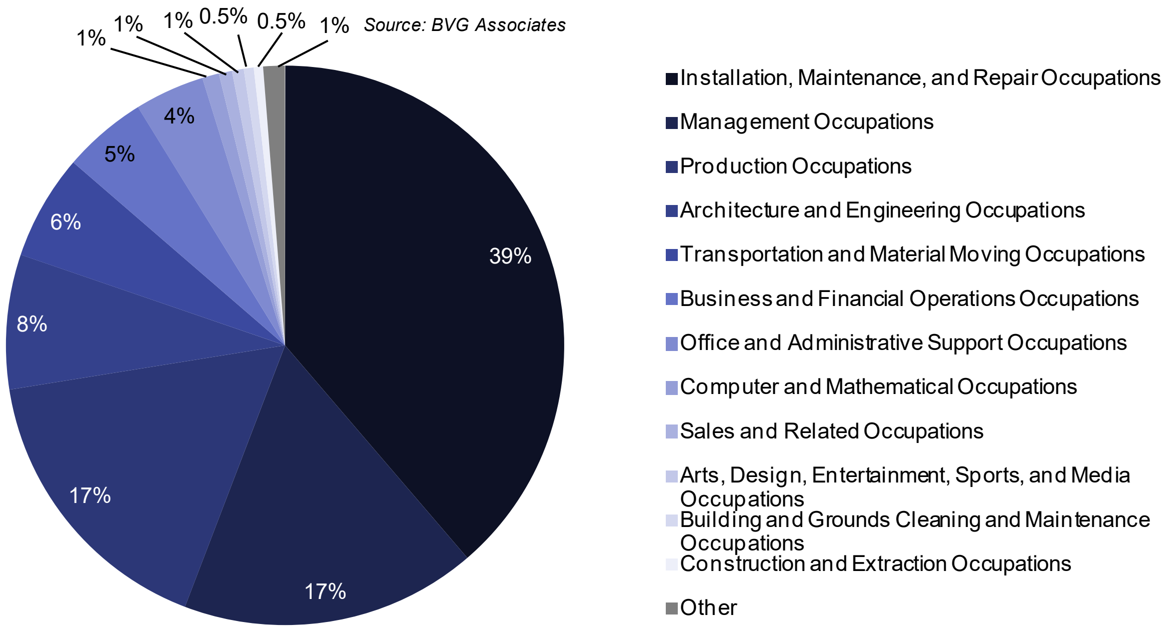
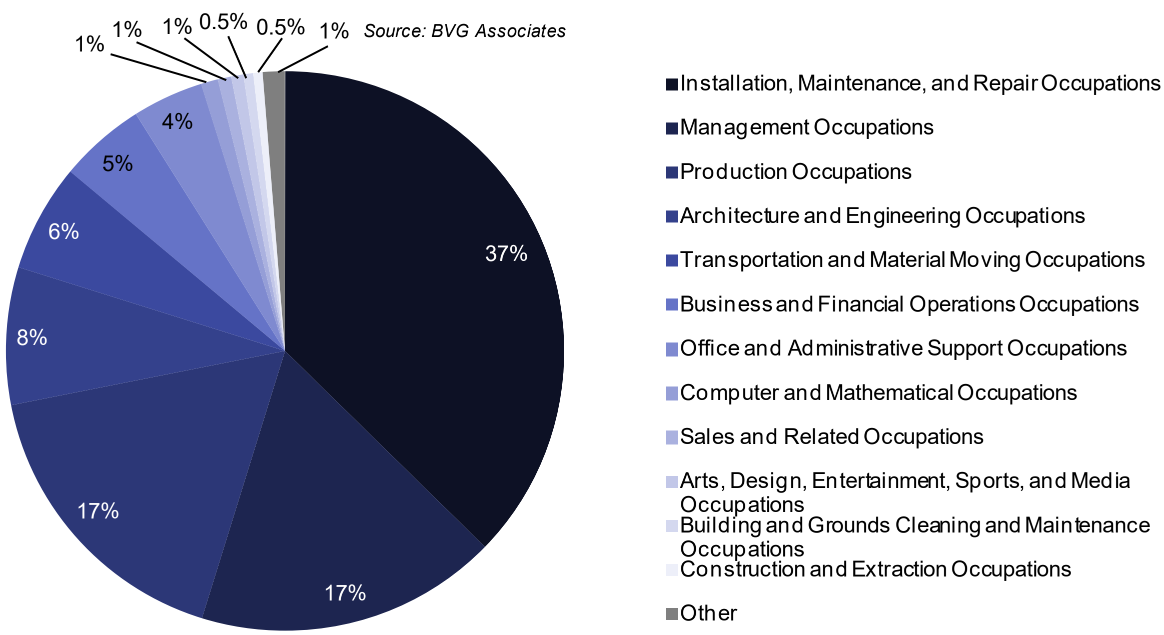


Figure 8. Baseline job offshore wind occupations by Standard Occupational Classification major group category

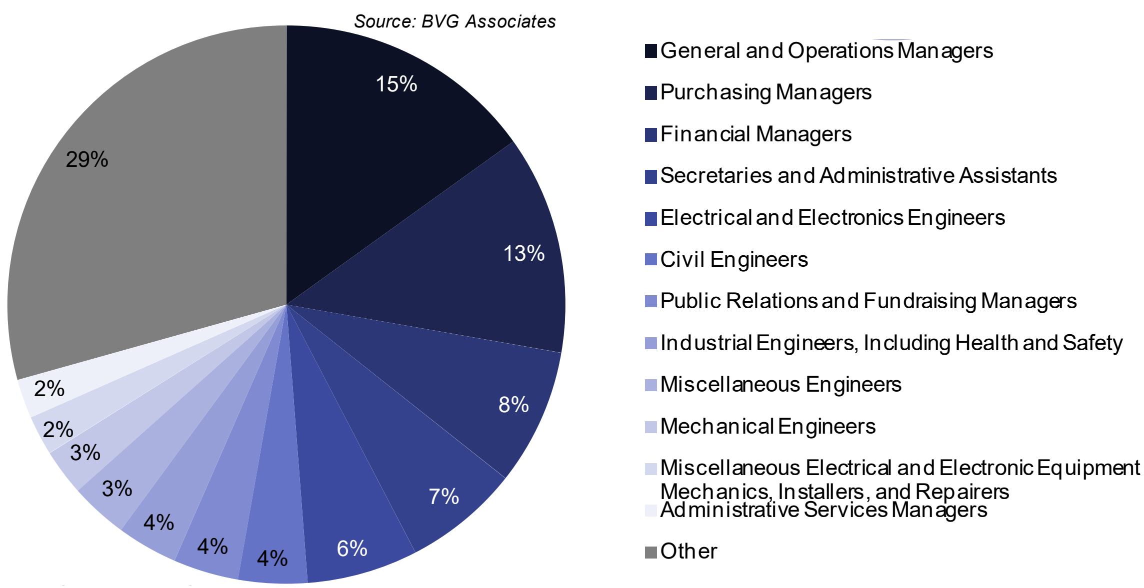


5.2 Project Development and Management

Between 2016 and 2056, project development and management creates 6,980 FTE years in the low scenario and 14,010 FTE years in the high scenario.

Figure 9 shows a wide range of occupations with a high proportion in general management positions and desk-based engineering occupations. There is also a large proportion of ‘other’ occupations, reflecting the diverse range of activities that take place at this stage, including geotechnical engineers, bird experts, and public relations professionals.

Figure 9. Occupations in project development and management

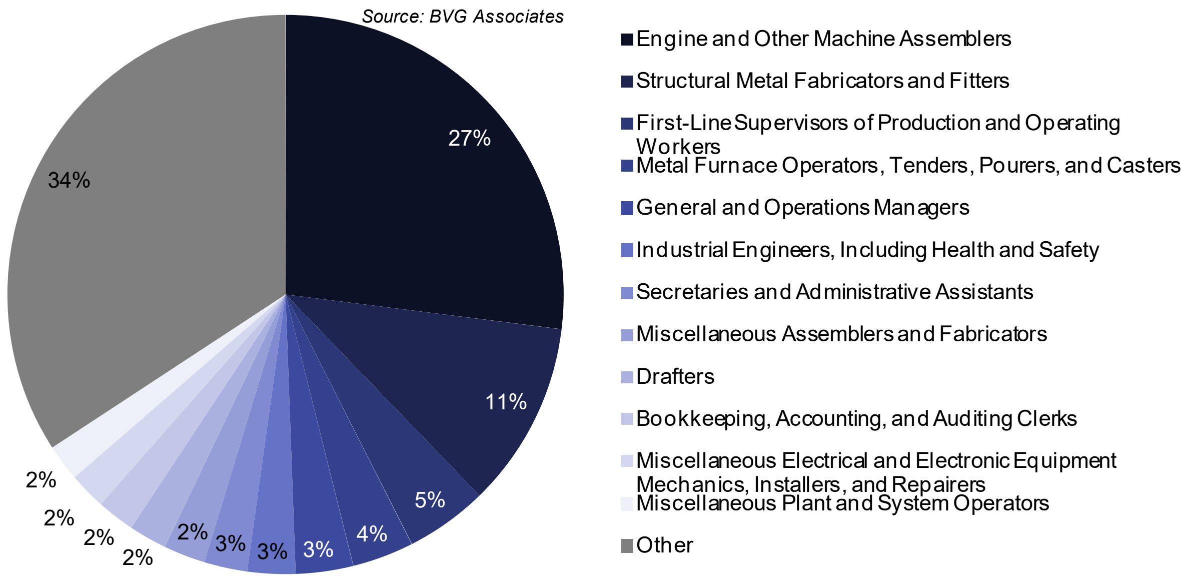


5.3 Turbine Supply

5.3.1 Nacelle, Hub, and Assembly

Between 2016 and 2056, nacelle, hub and assembly creates 24,700 FTE years in the low scenario and 49,580 FTE years in the high scenario. Figure 10 shows a large proportion of the jobs in factory assembly, but also with a significant number involved in metal structures manufacturing.

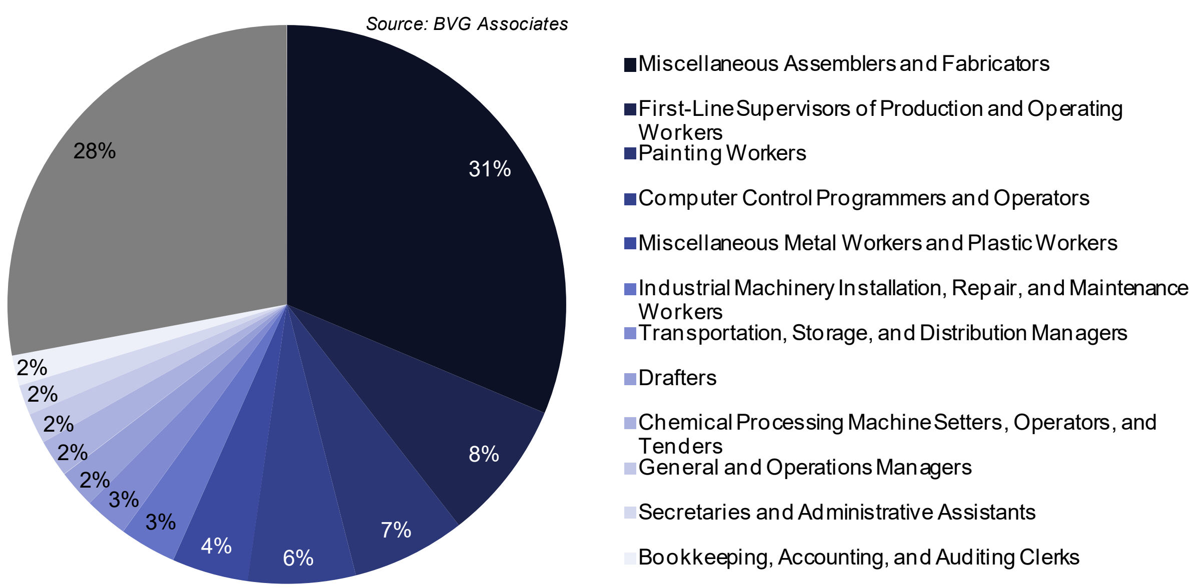
Figure 10. Occupations in nacelle, hub and assembly



5.3.2 Blades

Between 2016 and 2056, blade manufacture creates 9,050 FTE years in the low scenario and 18,170 FTE years in the high scenario. Figure 11 shows significant proportion involved in factory floor manufacturing roles (miscellaneous assemblers and fabricators) reflecting the fact that blade manufacture is still largely a manual process.

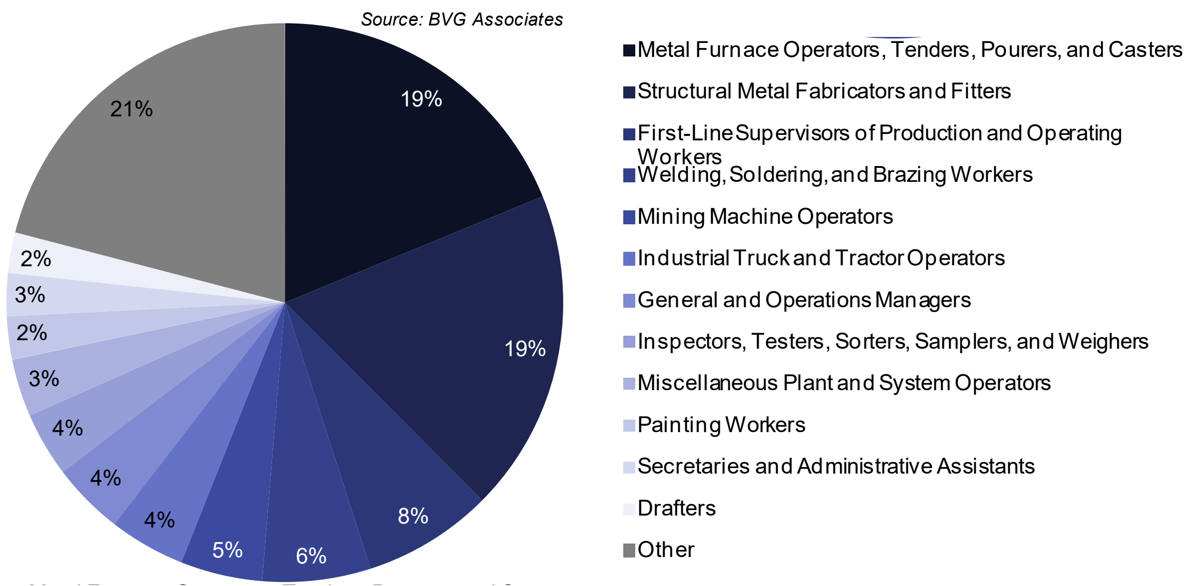
Figure 11. Occupations in blade manufacture



5.3.3 Tower

Between 2016 and 2056, tower manufacture creates 3,060 FTE years in the low scenario and 6,140 FTE years in the high scenario. Figure 12 shows a high proportion of the jobs in steel production and fabrication. Tower manufacture typically uses automated processes and the supply of steel plate is a major part of the cost.

Figure 12. Occupations in tower manufacture

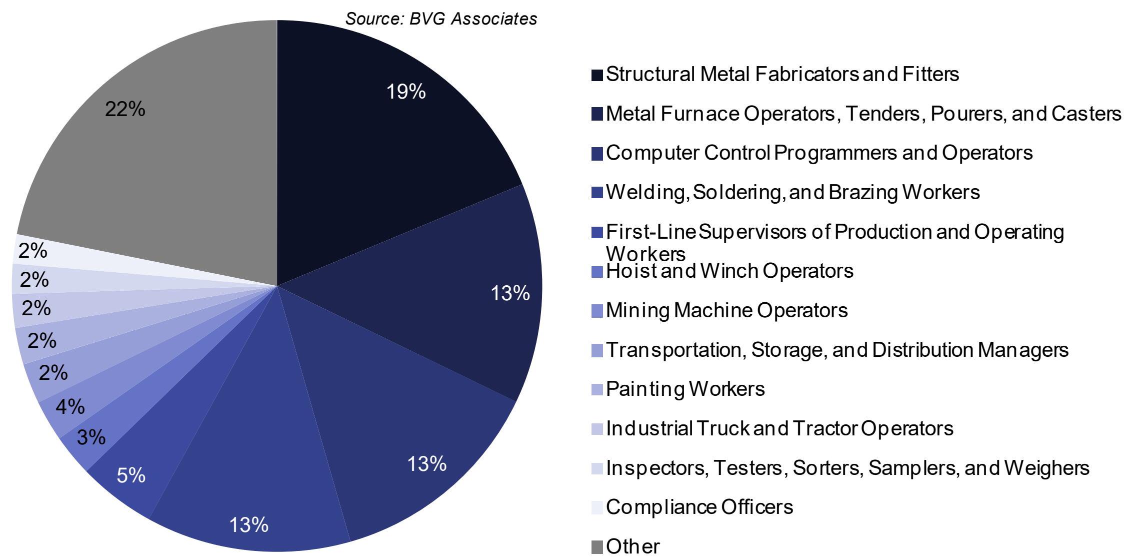


5.4 Balance of Plant

5.4.1 Foundation Supply

Between 2016 and 2056, foundation manufacture creates 18,360 FTE years in the low scenario and 36,860 FTE years in the high scenario. Figure 13 shows, compared with tower manufacture, a higher proportion of jobs in steel fabrication roles than in steel production. This is because much of the fabrication work for jackets and the transition piece for monopiles involves more manual welding and the work to produce steel plates accounts for less of the overall cost. It is assumed that the U.S. will use a combination of jacket and monopile steel foundations.

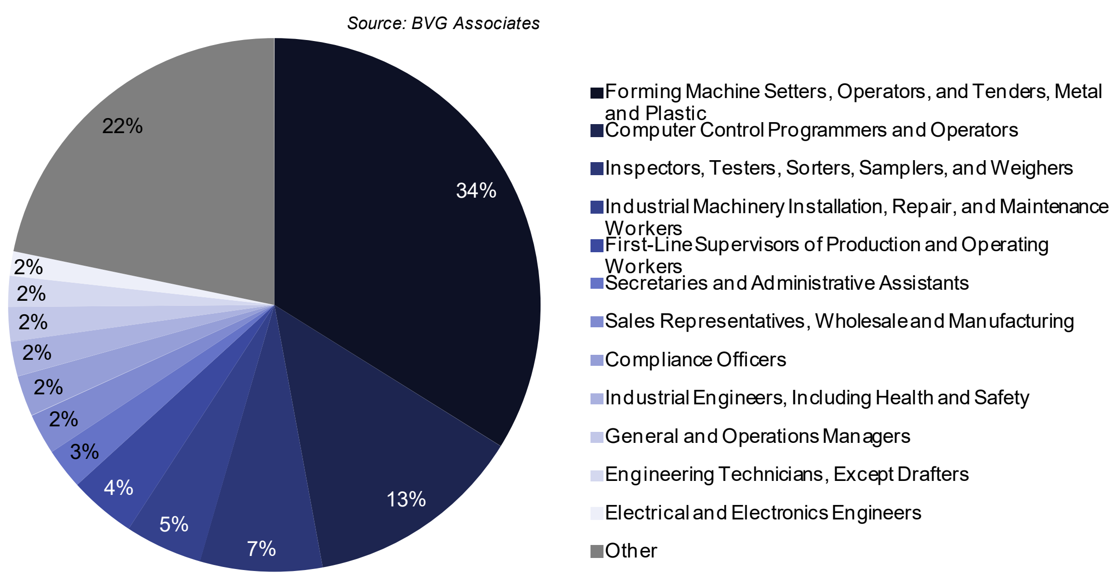
Figure 13. Occupations in foundation manufacture



5.4.2 Array Cable and Export Cable Supply

Array and export cable supply have been analyzed together because the occupations are similar. Between 2016 and 2056, they create 18,200 FTE years in the low scenario and 36,550 FTE years in the high scenario. The manufacturing process is largely automated with a significant proportion involved in the operation of the cable assembly lines (notably Forming Machine Setters, Operators, and Tenders, Metal, and Plastic) as shown in Figure 13.

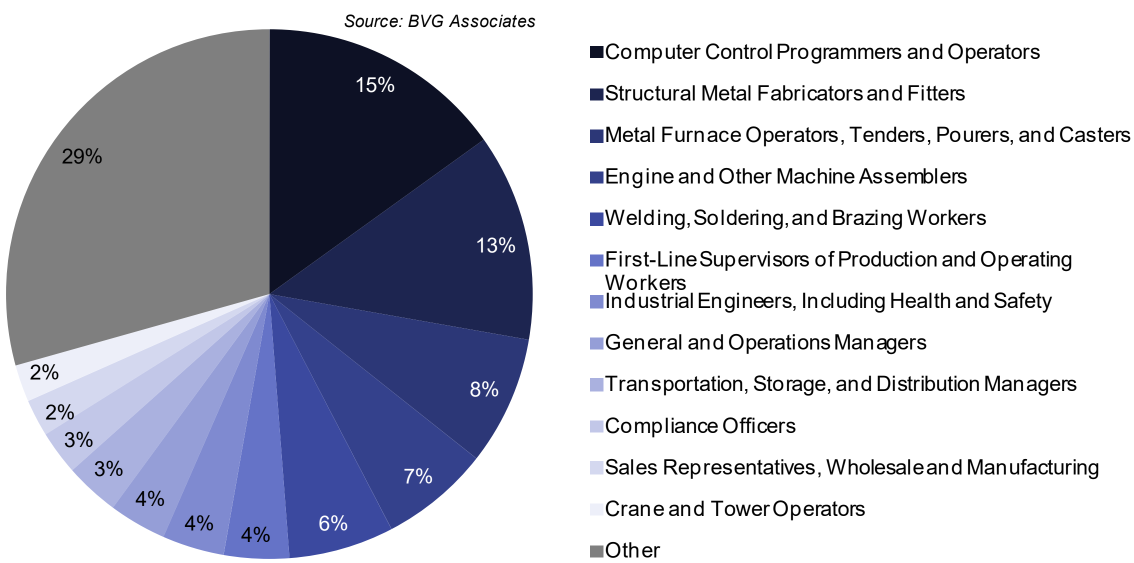
Figure 14. Occupations in array and export cable supply



5.4.3 Substation Supply

Between 2016 and 2056, substation supply creates 18,920 FTE years in the low scenario and 37,980 FTE years in the high scenario. Figure 15 shows that it supports a diverse range of occupations with significant numbers in the design and manufacture of electrical components and systems as well as heavy steel fabrication. The manufacturing processes for electrical components are automated, hence the high proportion of computer control programmers and factory equipment operators. The high steel content in the substation structure means steel manufacturing and fabrication occupations are well represented.

Figure 15. Occupations in substations supply

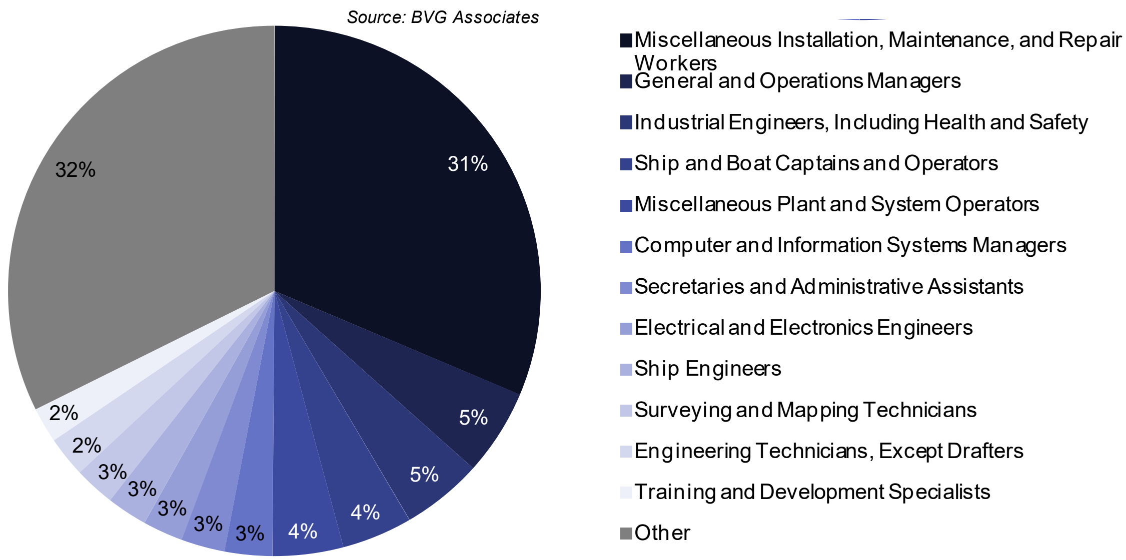


5.5 Installation and Commissioning

5.5.1 Foundation Installation

Between 2016 and 2056, foundation installation creates 9,950 FTE years in the low scenario and 19,980 FTE years in the high scenario. Figure 16 shows a high proportion of the jobs created are classified as installation, maintenance, and repair, which reflects the significant use of offshore riggers.

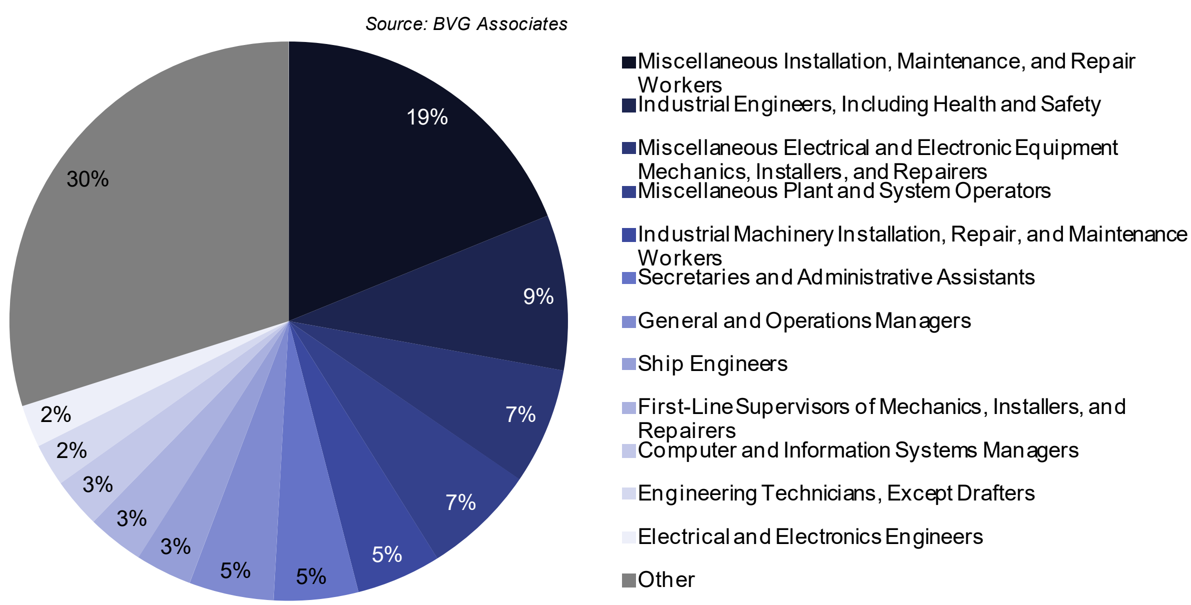
Figure 16. Occupations in foundation installation



5.5.2 Subsea Cable Installation

Between 2016 and 2056, subsea cable installation creates 15,970 FTE years in the low scenario and 32,060 FTE years in the high scenario. Figure 17 shows a wide range of occupations with a high proportion working offshore such as engineering technicians and construction workers (included in Miscellaneous Installation, Maintenance, and Repair Workers).

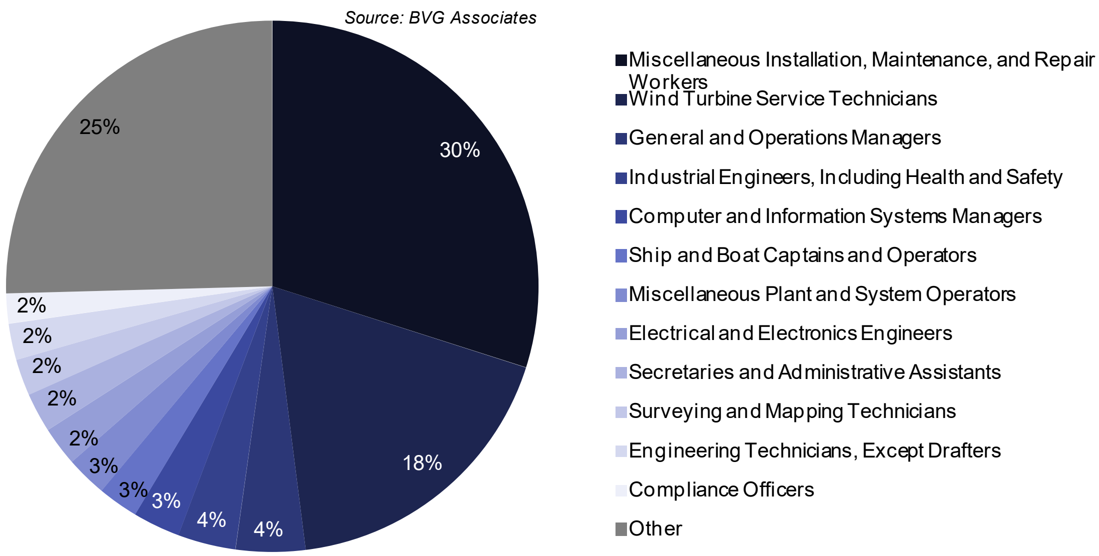
Figure 17. Occupations in subsea cable installation



5.5.3 Turbine Installation

Between 2016 and 2056, turbine installation creates 4,870 FTE years in the low scenario and 9,790 FTE years in the high scenario. Figure 16 shows a high proportion of the jobs created are classified as installation, maintenance, and repair, which reflects the use of offshore riggers. There are similarities with foundation installation, but the key difference is the use of turbine technicians during the commissioning process. The SOC classification is strictly for maintenance technicians, but the commissioning teams use similar skills.

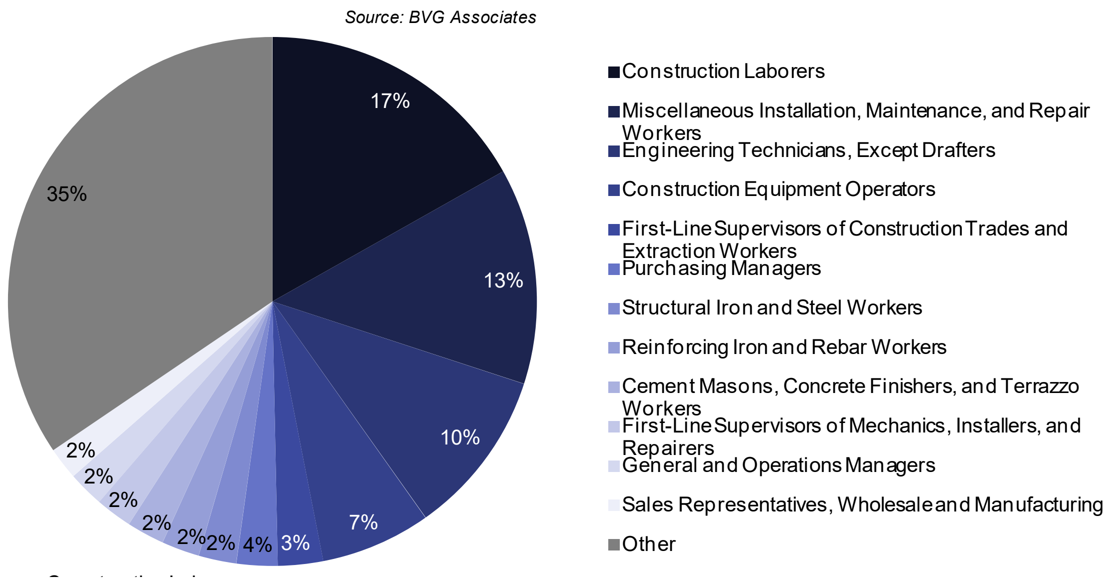
Figure 18. Occupations in turbine installation



5.5.4 Other Installation

Other installation mainly covers the installation of the offshore substation, the construction of the onshore substation, and the installation on the onshore cable. Between 2016 and 2056, other installation creates 3,650 FTE years in the low scenario and 7,330 FTE years in the high scenario. Figure 19 demonstrates the range of activities with onshore construction as the main occupation, closely followed by miscellaneous installation, maintenance, and repair workers, who are mainly the offshore substation installation crew.

Figure 19. Occupations in other installation

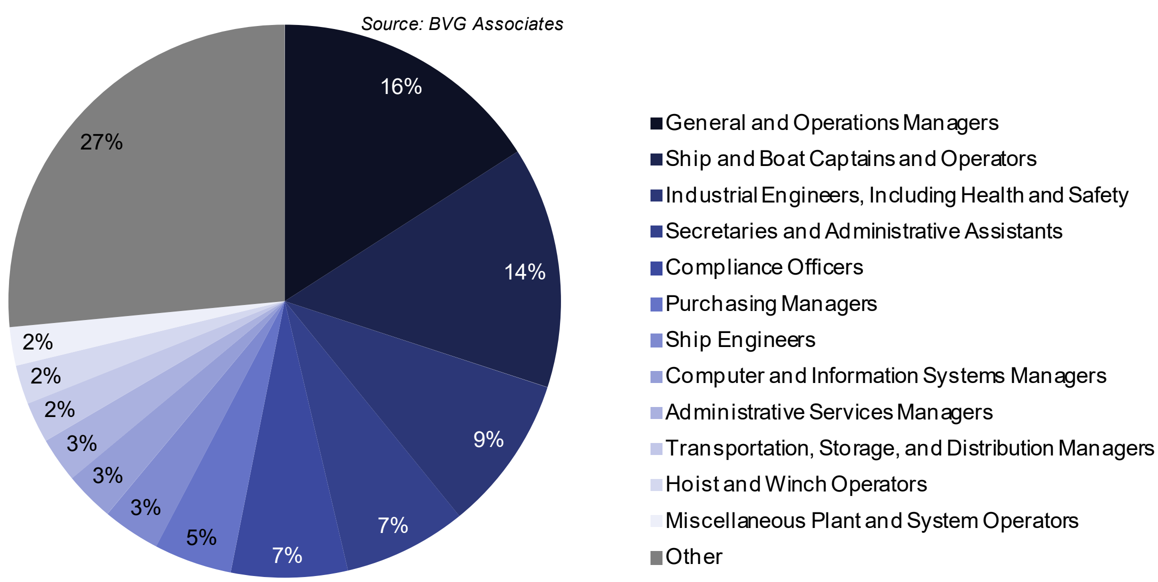


5.6 Operations, Maintenance, and Service

5.6.1 Wind Farm Operations

Between 2016 and 2056, wind farm operation creates 32,030 FTE years in the low scenario and 64,290 FTE years in the high scenario. Figure 20 shows a wide range of occupations with a high proportion in vessel operations and in general operations.

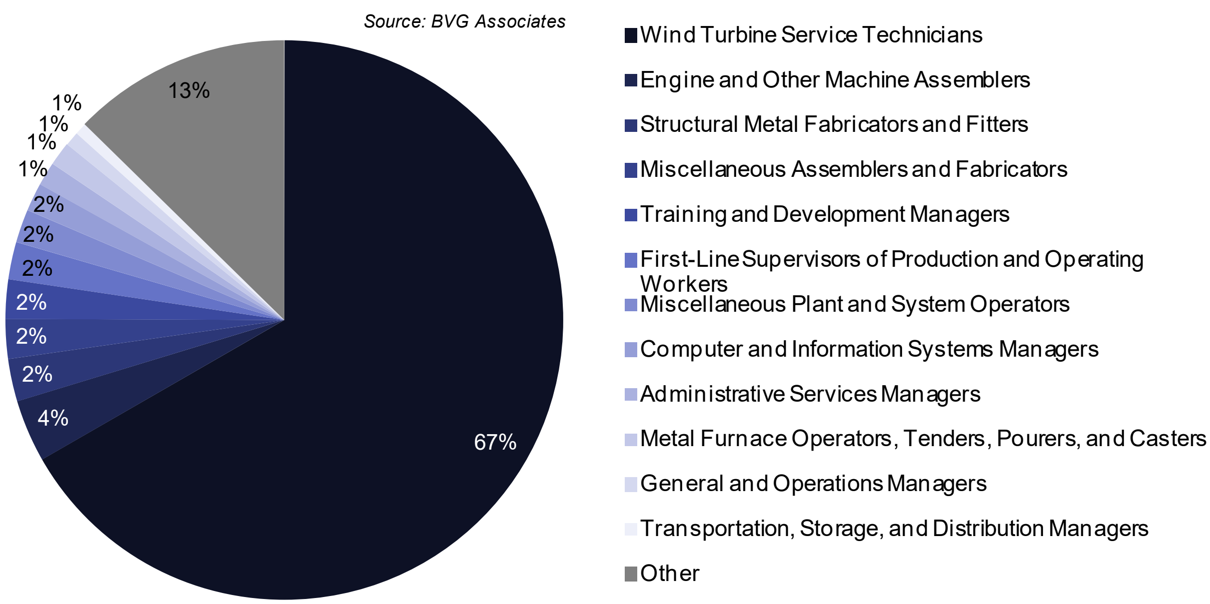
Figure 20. Occupations in wind farm operations



5.6.2 Turbine Maintenance and Service

Between 2016 and 2056, turbine maintenance and service creates 74,240 FTE years in the low scenario and 149,050 FTE years in the high scenario. Figure 21 shows that these are mainly wind turbine service technicians, although significant numbers of jobs are also created through the manufacture of replacement components and in the repair or refurbishment of components.

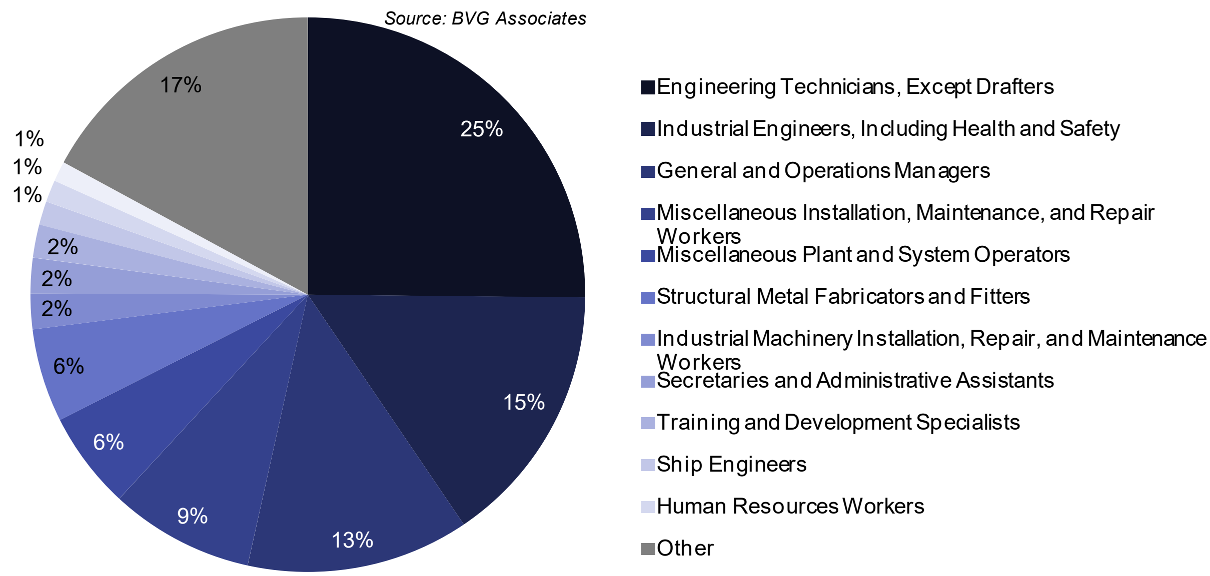
Figure 21. Occupations in turbine maintenance and service



5.6.3 Foundation Maintenance and Service

Between 2016 and 2056, foundation maintenance and service creates 2,440 FTE years in the low scenario and 4,890 FTE years in the high scenario. Figure 22 shows the biggest areas of job creation are engineering technicians and industrial engineers followed by a range of operational and managerial roles.

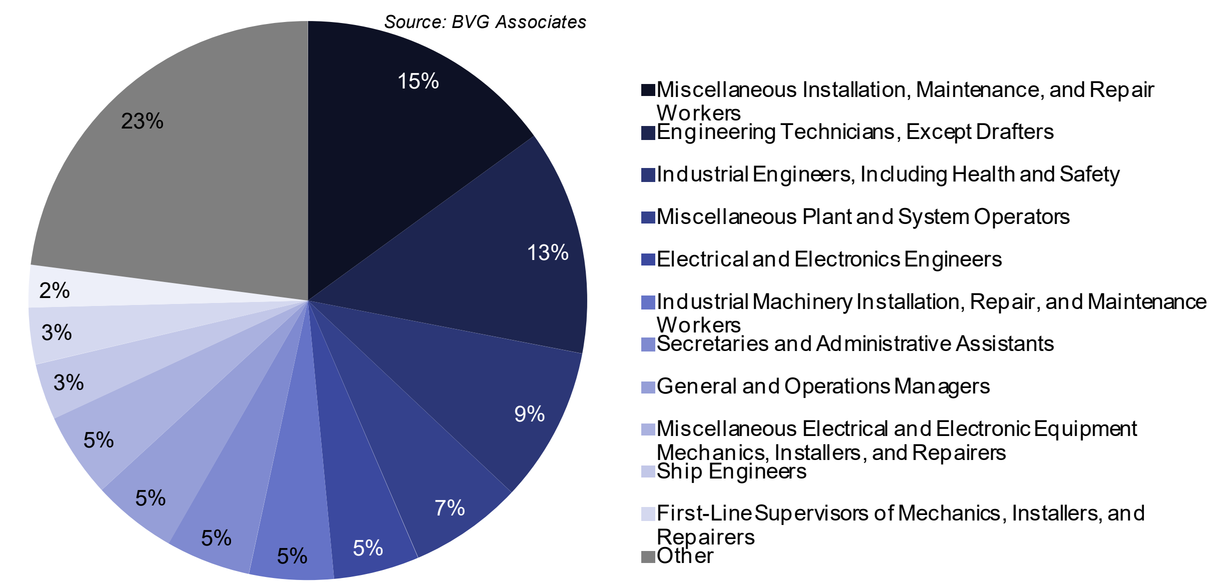
Figure 22. Occupations in foundation maintenance and service



5.6.4 Subsea Cable Maintenance and Service

Between 2016 and 2056, subsea cable maintenance and service creates 4,250 FTE years in the low scenario and 8,540 FTE years in the high scenario. Figure 23 shows a wide range of occupations, as the work needs a variety of roles from the manufacture of replacement cables and joints to the work involved in replacing or repairing the offshore cables.

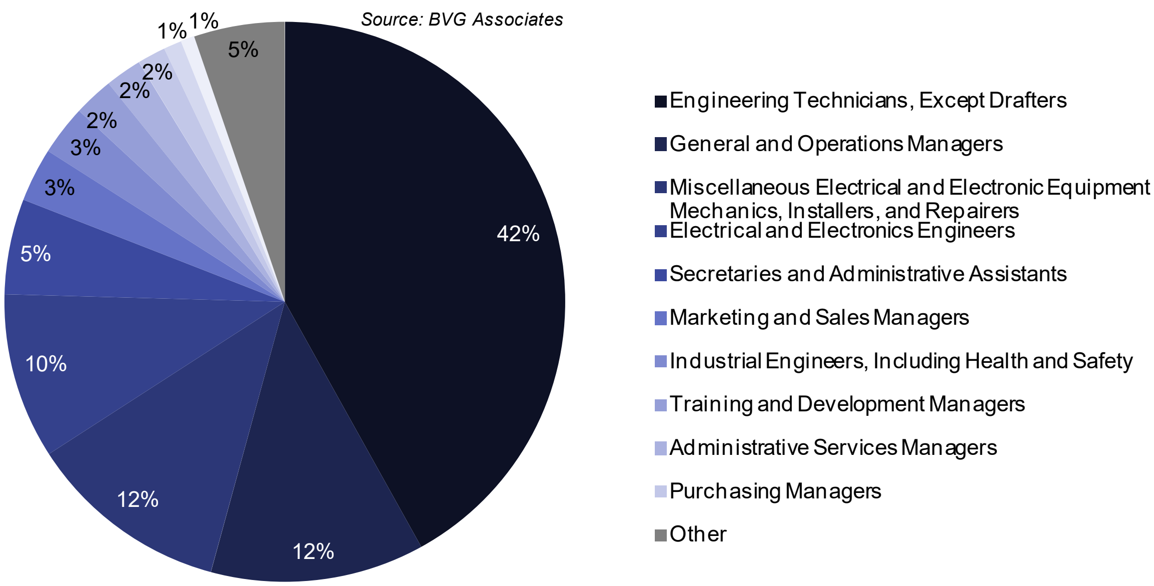
Figure 23. Occupations in subsea cable maintenance and service



5.6.5 Substation Maintenance and Service

Between 2016 and 2056, substation maintenance and service creates 1,920 FTE years in the low scenario and 3,850 FTE years in the high scenario. Figure 24 shows the main demand will be for engineering technicians, in this case with electrical training, both for substation maintenance and the supply of replacement parts.

Figure 24. Occupations in substation maintenance and service



6 Discussion

6.1 U.S. Job Creation

This analysis indicates that in the low scenario, 248,000 FTE job years are created globally in the offshore wind supply chain. This rises to 500,000 in the high scenario.

A high percentage of these jobs will be created in the U.S., but some will be generated elsewhere. The analysis divides the total number of jobs into baseline jobs (those almost certainly created in the U.S. to supply offshore wind farms) and additional jobs with either a high, medium, or low probability of being created in the U.S. In both scenarios, about 65% of the FTE years are categorized as baseline (160,400 FTE job years in the low scenario and 322,010 FTE job years in the high scenario). Although the high scenario makes additional jobs more likely, it does not lead to a higher proportion of baseline jobs because U.S. companies will still meet significant competition from more established suppliers and U.S. supply cannot be guaranteed.

Baseline jobs include occupations involved in project management and development where the knowledge of local conditions and the consenting environment are important and where the U.S. has skills from other sectors that can be easily applied. Many of the jobs are in engineering, procurement, and operations management.

The jobs created in the operational phase are also baseline. Many of these involve daily work on the wind farms in hands-on supporting roles. These jobs are particularly valuable to the U.S. economy because there will be a long-term demand for this work and it will not be subject to annual variations in the market for the products and services needed for construction. Many of the occupations in the operational phase are wind turbine technician roles, although there will also be strong demand for vessel crews.

Excluded from the list of baseline jobs are those associated with turbine supply. Although the U.S. has a significant onshore turbine industry, most offshore wind jobs can only be created with investment in coastal facilities. While the importing of turbine components from European factories is costly, investment by a turbine supplier in the U.S. requires strong confidence in a long-term market and the prospect of supplying at least 500MW of turbines annually. With three or more turbine suppliers competing in the U.S., an annual market closer to 1GW is needed for one supplier to be confident of securing 500MW. In the low market scenario, nacelle, hub, and assembly is low probability, and towers and blades are medium probability. In the high scenario, the U.S. job prospects improve and jobs in blades and towers become high probability.

Blade and tower factories are likely to be the first U.S. investments in turbine component factories. The supply chains are independent of other turbine components and only need to come together during offshore construction. Investment in turbine nacelle assembly is likely to come more slowly than blades or towers because the turbine manufacturer needs to see commitments from main suppliers to also invest in U.S. manufacturing facilities; therefore, the business case for them to do so may be less compelling.

In theory, turbine components could be supplied from onshore wind factories, but these are typically inland and components are mostly too large to move by road. The dimensions of offshore components may also preclude the use of existing facilities.

The study concludes that foundation supply creates additional jobs with a high probability in both scenarios. The U.S. has the necessary skills from the offshore oil, gas, and shipbuilding industries to build large steel structures, although companies and their workforces will need to make the adjustments for volume manufacture. About half the jobs in foundation supply are created by steel-making and steel fabrication. With offshore wind creating many of these jobs in or close to ports, it can play an important role in the transition from traditional industries.

The situation with vessels is made more complex by the Jones Act. A study commissioned by the Roadmap Project concluded that a new-build compliant vessel was viable with a 4GW pipeline. Plans have also been announced to convert a compliant vessel. In the low market scenario, the investment case for a vessel does not appear strong. A feeder solution using a European vessel is likely to remain the base case for a commercial project developer. The high scenario would create a stronger case for investment in a U.S.-built vessel.

In general, both baseline and high probability jobs cover approximately 50% of FTE years in the low scenario in the late 2020s. In the high scenario, this rises to 70% due to sufficient visible pipeline to trigger major investments in new factories and vessels. The key aspect is pipeline visibility. Investment is only likely if an investor has confidence in market demand more than three to five years ahead. In many cases, the high scenario is the tipping point, making investments much more likely.

If both medium and high probability jobs are considered, as well as baseline jobs, the outlook for U.S. is much more favorable in the high scenario than in the low scenario. In the low scenario, there would be a total of 195,500 FTE U.S. job years, with a peak of 12,300 FTE jobs in 2028. For the high scenario, there would be 499,000 FTE job years, with a peak of 35,550 FTE jobs in 2027.

6.2 Occupations

The analysis identified 109 different occupations under the SOC system, excluding those in general business services and equipment supply. Of the 500,000 jobs in the high scenario and 248,000 in the low scenario, 75% are spread between three major categories:

- Installation, repair and maintenance occupations
- Management occupations
- Production occupations

There are two main conclusions.

The first is that offshore wind creates a significant demand for general skilled workers. All companies active in the sector employ people in leadership and administrative functions such as IT, human resources, finance, and sales and marketing. Equally, all companies also procure a range of office services, equipment, and consumables. Together, these may form about a third of the jobs created by the offshore wind industry. They show that the economic benefits of offshore wind will be felt widely in the workforce.

The second is that there is a significant demand for technician level workers. These may be in:

- Production roles, particularly in high value manufacturing positions
- Installation and commissioning positions, vessel and offshore equipment operation, and commissioning and testing turbines, cables, and substations
- Operation, maintenance, and service roles, particularly turbine technicians

Although these technician roles are quite diverse, many will initially follow similar training paths. Suppliers to the wind industry will not anticipate specialist training before investing, but will expect an available general technically skilled workforce. A relevant example is Siemens-Gamesa's investment in a blade manufacturing factory in Hull, UK. On committing to the factory, there were few workers in the area with any experience of blade manufacturing or composites. Between making its investment decision and the opening of the facility, Siemens-Gamesa recruited and trained the individuals from a local workforce with core manufacturing skills.

Key to attracting investment will be ensuring there is a workforce with these core technical skills. Initiatives to build these general technical skills, rather than highly specialist skills, have the advantage of application in a range of sectors and can contribute widely to improvements in productivity. There is therefore little risk that investments in skills development will be wasted.

A particular value of offshore wind jobs is that many are created in industrialized coastal areas, which have suffered from economic decline in recent years in many cases. Offshore wind can play an important part in reversing that situation.

Appendix A. Economic Model

A.1 Background

Conventional modeling of economic impacts for most industrial sectors relies on government statistics; for example, those based on North American Industry Classification System (NAICS) and use input-output tables and other production and employment ratios, such as those produced at Federal level by the Department of Commerce Bureau of Economic Statistics

NAICS code data can be appropriate for traditional industries at a national level. However, the development of new codes for a maturing sector takes time. This means conventional economic analyses of offshore wind need to map existing NAICS data onto offshore wind activities, which is not easy and a source for error. Analyses using SIC codes also rely on generalized data.

Offshore wind is ideally suited to a more robust approach that considers current and future capability of local supply chains because projects tend be large with distinct procurement processes, use comparable technologies, and share supply chains. Therefore, it enables a realistic analysis of the local, regional, and national content of projects even where there are gaps in the data.

A.2 Methodology

The methodology's first input is the cost per MW of each of the 18 supply chain subelements at the time of wind farm completion. The study used data for U.S. wind farms developed from work currently underway with NYSERDA.

The study considered all the jobs created in the supply chain, other than those from construction of capital assets. The next step was to estimate how much of the cost of each subelement would be formed by the depreciated cost of these capital assets.

The remaining expenditure is analogous to the direct and indirect gross value added (GVA) created. GVA is the aggregate of labor costs and operational profits; therefore, modeling FTE employment from GVA, provided key variables are understood. In the economic impact methodology, employment impacts are calculated using the following equation:

Equation 1. $FTE_a = \frac{(GVA - M)}{Y_a + W_a}$

Where:

FTE_a = Annual FTE employment
GVA = Gross value added ($)
M = Total operating margin ($)
Y_a = Average annual wage ($), and
W_a = Non-wage average annual cost of employment ($).

To make robust assessments, each major component in the offshore wind supply chain is considered with estimates of typical salary levels, costs of employment, and profit margins. This brings together BVGA's specific sector knowledge and research into typical labor costs for the work undertaken in each supply chain subelement. The study did not consider induced job creation, which is the result of personal expenditure of the labor force.

Appendix B. Offshore Wind Farm Occupations

Code	Occupation	FTE years	
		Low (4GW)	High (8GW)
11-1010	Chief Executives	1,084	2,177
11-1020	General and Operations Managers	9,126	18,322
11-2020	Marketing and Sales Managers	593	1,190
11-2030	Public Relations and Fundraising Managers	1,081	2,170
11-3010	Administrative Services Managers	2,761	5,543
11-3020	Computer and Information Systems Managers	,244	6,512
11-3030	Financial Managers	1,833	3,681
11-3050	Industrial Production Managers	792	1,590
11-3060	Purchasing Managers	3,193	6,409
11-3070	Transportation, Storage, and Distribution Managers	2,711	5,442
11-3120	Human Resources Managers	702	1,409
11-3130	Training and Development Managers	2,891	5,804
13-1040	Compliance Officers	3,894	7,817
13-1070	Human Resources Workers	1,645	3,302
13-1080	Logisticians	1,053	2,113
13-1150	Training and Development Specialists	1,201	2,412
13-1190	Miscellaneous Business Operations Specialists	42	84
13-2010	Accountants and Auditors	1,181	2,370
13-2050	Financial Analysts and Advisors	187	376
15-1120	Computer and Information Analysts	125	252
15-1130	Software Developers and Programmers	249	500
15-1150	Computer Support Specialists	1,095	2,198
15-2010	Actuaries	79	158
15-2030	Operations Research Analysts	232	466
17-2040	Chemical Engineers	106	213
17-2050	Civil Engineers	280	561
17-2070	Electrical and Electronics Engineers	1,892	3,798

Code	Occupation	FTE years	
17-2110	Industrial Engineers, Including Health and Safety	6,666	13,382
17-2120	Marine Engineers and Naval Architects	271	544
17-2130	Materials Engineers	95	191
17-2140	Mechanical Engineers	480	964
17-2150	Mining and Geological Engineers, Including Mining Safety Engineers	72	546
17-2190	Miscellaneous Engineers	234	469
17-3010	Drafters	1,737	3,487
17-3020	Engineering Technicians, Except Drafters	3,455	6,937
17-3030	Surveying and Mapping Technicians	446	896
19-1020	Biological Scientists	9	18
19-1030	Conservation Scientists and Foresters	66	132
19-2030	Chemists and Materials Scientists	174	349
19-2040	Environmental Scientists and Geoscientists	123	247
19-3010	Economists	67	135
19-3020	Survey Researchers	33	67
19-3050	Urban and Regional Planners	33	67
19-4020	Biological Technicians	36	72
19-4040	Geological and Petroleum Technicians	71	143
23-1010	Lawyers and Judicial Law Clerks	472	947
23-2010	Paralegals and Legal Assistants	399	801
27-3030	Public Relations Specialists	1,333	2,676
35-2010	Cooks	284	571
35-2020	Food Preparation Workers	580	1,165
37-1010	First-Line Supervisors of Building and Grounds Cleaning and Maintenance Workers	438	879
37-2010	Building Cleaning Workers	811	1,629
41-1010	First-Line Supervisors of Sales Workers	212	426
41-4010	Sales Representatives, Wholesale and Manufacturing	2,244	4,505
43-1010	First-Line Supervisors of Office and Administrative Support Workers	837	1,680
43-2090	Miscellaneous Communications Equipment Operators	234	469
43-3030	Bookkeeping, Accounting, and Auditing Clerks	1,386	2,783

Code	Occupation	FTE years	
43-6010	Secretaries and Administrative Assistants	4,846	9,728
43-9040	Insurance Claims and Policy Processing Clerks	658	1,320
47-1010	First-Line Supervisors of Construction Trades and Extraction Workers	300	602
47-2020	Brickmasons, Blockmasons, and Stonemasons	27	54
47-2030	Carpenters	46	91
47-2040	Carpet, Floor, and Tile Installers and Finishers	13	27
47-2050	Cement Masons, Concrete Finishers, and Terrazzo Workers	67	135
47-2060	Construction Laborers	524	1,051
47-2070	Construction Equipment Operators	197	395
47-2110	Electricians	46	91
47-2140	Painters and Paperhangers	13	27
47-2150	Pipelayers, Plumbers, Pipefitters, and Steamfitters	46	91
47-2170	Reinforcing Iron and Rebar Workers	67	135
47-2180	Roofers	13	27
47-2220	Structural Iron and Steel Workers	67	135
47-4010	Construction and Building Inspectors	4	7
47-5030	Explosives Workers, Ordnance Handling Experts, and Blasters	132	265
47-5040	Mining Machine Operators	1,050	2,108
49-1010	First-Line Supervisors of Mechanics, Installers, and Repairers	1,133	2,275
49-2090	Miscellaneous Electrical and Electronic Equipment Mechanics, Installers, and Repairers	2,567	5,154
49-3050	Small Engine Mechanics	793	1,592
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	2,591	5,203
49-9080	Wind Turbine Service Technicians	40,319	80,942
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	7,593	15,244
51-1010	First-Line Supervisors of Production and Operating Workers	4,927	9,891
51-2030	Engine and Other Machine Assemblers	8,469	17,002
51-2040	Structural Metal Fabricators and Fitters	9,137	18,343
51-2090	Miscellaneous Assemblers and Fabricators	4,115	8,261
51-4010	Computer Control Programmers and Operators	7,351	14,759
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	4,931	9,899

Code	Occupation	FTE years	
51-4030	Machine Tool Cutting Setters, Operators, and Tenders, Metal and Plastic	367	736
51-4050	Metal Furnace Operators, Tenders, Pourers, and Casters	5,296	10,632
51-4060	Model Makers and Patternmakers, Metal and Plastic	6	12
51-4070	Molders and Molding Machine Setters, Operators, and Tenders, Metal and Plastic	155	310
51-4120	Welding, Soldering, and Brazing Workers	2,826	5,674
51-4190	Miscellaneous Metal Workers and Plastic Workers	750	1,506
51-8030	Water and Wastewater Treatment Plant and System Operators	108	216
51-8090	Miscellaneous Plant and System Operators	4,396	8,826
51-9010	Chemical Processing Machine Setters, Operators, and Tenders	450	904
51-9040	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	613	1,232
51-9060	Inspectors, Testers, Sorters, Samplers, and Weighers	2,316	4,649
51-9120	Painting Workers	1,560	3,132
53-1030	First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators	154	310
53-3030	Driver/Sales Workers and Truck Drivers	429	862
53-5020	Ship and Boat Captains and Operators	4,243	8,518
53-5030	Ship Engineers	1,722	3,457
53-7020	Crane and Tower Operators	1,234	2,477
53-7030	Dredge, Excavating, and Loading Machine Operators	23	46
53-7040	Hoist and Winch Operators	1,565	3,141
53-7050	Industrial Truck and Tractor Operators	1,378	2,766
53-7120	Tank Car, Truck, and Ship Loaders	216	434
53-7190	Miscellaneous Material Moving Workers	258	517
	Other general business services and equipment	49,719	99,815
	Total	248,595	499,073

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U.S. Job Creation in Offshore Wind

A Report for the Roadmap Project for Multi-State Cooperation on Offshore Wind

New York State Energy Research and Development Authority
Massachusetts Clean Energy Center
Massachusetts Department of Energy Resources
Rhode Island Office of Energy Resources
Clean Energy States Alliance

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