Massachusetts Clean Energy Center

Offshore Wind Supply Chain Assessment and Development Support

Final Report

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1 INTRODUCTION

1.1 General

With a project pipeline of more than 30,000 MW in awarded lease areas and 14 projects, equating to over 9 GW in capacity, currently expected to be operational by 2026, the US offshore wind (OSW) market now represents a sizeable portion of the global offshore wind market.

The Commonwealth of Massachusetts (MA) has been at the forefront of this nascent industry and has set out a bold agenda to become a national hub for the emerging industry along the East Coast. With 7-10 GW estimated for deployment in the region before the end of the decade, OSW presents a significant opportunity to help the Commonwealth meet its greenhouse gas (GHG) emission reduction mandates and goals, address the retirement of aging power plants, provide economic development opportunities for MA businesses, and create thousands of jobs for MA residents.

However, in order to realize this market potential, the following key project hurdles need to be addressed at a national level and supported at a regional level.

- Primarily, the project permitting process has, to date, delayed the acceleration of the US industry. The Vineyard Wind project received approval on its final environmental impact statement (FEIS) on March 12th of 2021; and received its Record of Decision (ROD) from BOEM in May 2021, the last approval required for construction on the project to begin. Approval for the Vineyard Wind project was originally expected for Q4 2019. This has had domino knock-on effect to other US projects and in particular those in the New England Region. The federal permitting process is expected to be a key bottleneck and risk to project delivery timelines.
- Directly related to the approval of the first commercial scale US project is the establishment of a local and/or regional supply chain to support the projects. Federal approval of the first project should, in theory, foster confidence that a sustainable and reliable pipeline of projects will come to fruition and, as such, investment in building the capabilities of the local supply chain will follow.

Building on the second point the current delivery model for the first commercial offshore wind farm (Vineyard Wind) is built on the import of the main components from overseas. Components for early projects will be imported to local ports to be staged before being transported to the project site for installation, and some components will be taken directly to the wind farm project site, foregoing local staging. Even though the large majority of project infrastructure will be imported initially, these projects are still generating significant economic activity in the project development phases. The projects will require significant support and services from local business during their construction/installation (over an 18-24-month period).

However, it is recognized that this delivery model will become increasingly inefficient and detrimental to the local economy. Therefore, MassCEC is supporting efforts to develop of a robust local supply chain in MA and throughout the

region that can manufacture and produce turbine components and associated equipment at a scale necessary to serve planned and anticipated offshore wind projects.

To support this ambition, MassCEC have engaged Xodus Group in order to learn more about supply chain needs and the specific supply chain capabilities that exist in MA and the region. The objective is to use these deeper supply chain insights to inform future strategic state-level investments and to help companies throughout the supply chain make more targeted and meaningful connections that lead to fruitful partnerships.

The economic benefit which MA can realize from offshore wind will depend to a great extent on the success of the local supply chain in winning and delivering work on offshore wind projects. While the MA market is expected to provide opportunities for the local supply chain, there will also be economic benefit to MA should local suppliers be successful in supporting projects along the entire US east coast and beyond.

In order to achieve this a clear path must be found for MA companies to develop further capabilities and facilities needed to be best in class, ensuring that those procuring products and services for projects in MA, the US and overseas have good visibility of local companies and their offerings. This study aims to identify local supply chain companies that will be able to match their capabilities to the opportunities presented by this growing industry both in MA and in export markets.

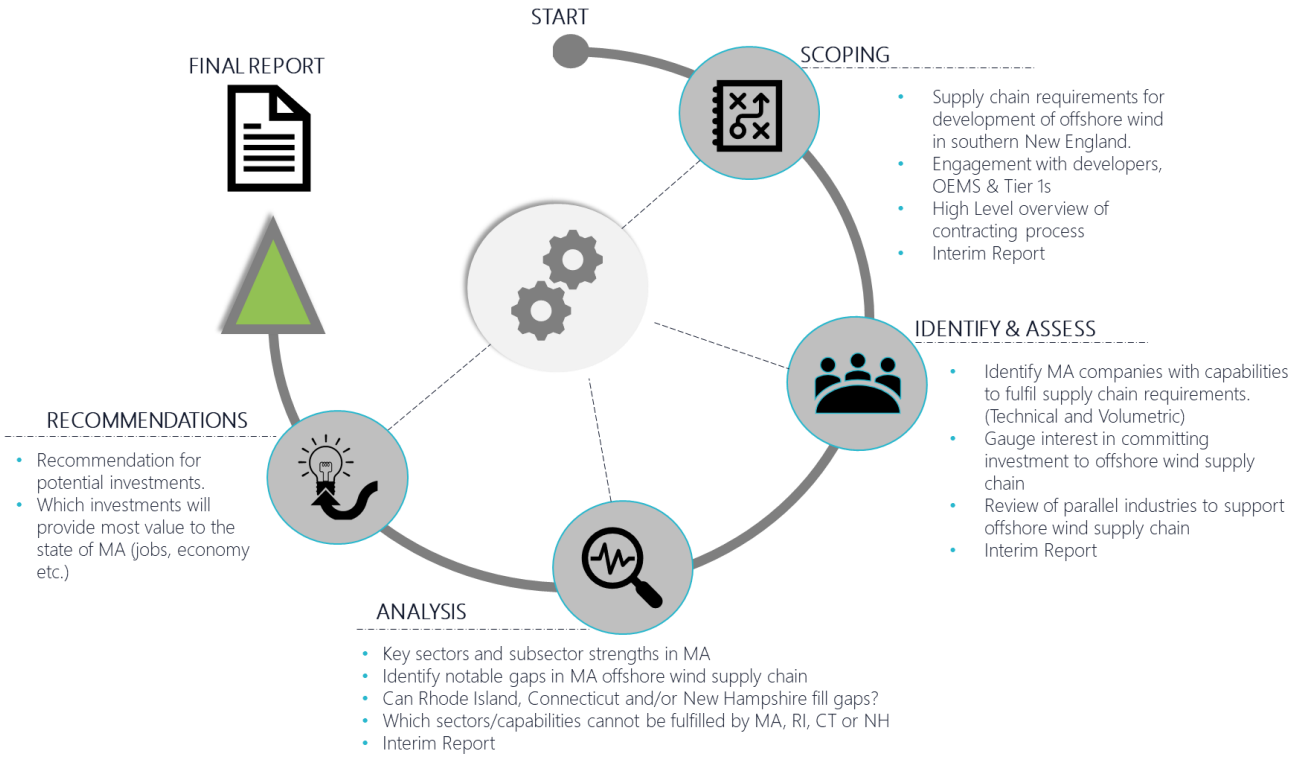


Figure 1-1 Project Overview

1.2 Objective

Xodus Group, in partnership with the BW Research, Inc. and MassCEC, have collaborated on this study to achieve the objective of putting forth a comprehensive offshore wind supply chain assessment and gap analysis for MA and the southern New England region, based on the requirements of both Developers and OEM/Tier 1's, and the capabilities, qualifications and interest of MA companies and neighboring states.

1.3 Scope of Document

The full scope of this project was split into two parts titled Service Area 1 and Service Area 2; the contents of this report are aligned with specific tasks that were set forth by MassCEC for the scope related to Service Area 1, which are as follows:

- Articulate the supply chain requirements for offshore wind in southern New England;
- Assess the capabilities, qualifications, and interest of MA companies to meet the articulated needs and requirements of the offshore wind industry.

Xodus Group and BW Research believe the proposed approach will allow MassCEC to develop an action plan for supporting and developing a robust local supply chain in MA. Importantly, this exercise will help local communities and businesses gain a deep understanding of the offshore wind supply chain landscape to further assist them in realizing the associated economic benefits. The key features of Service Area 1, were broken down into more specific areas which included:

A. Scoping the supply chain requirements
B. Identifying and assessing key sectors/sub-sectors
C. Analyzing strengths and limitations of MA and comparing to neighboring states
D. Recommendations for MA for potential investments

The way in which each of these key features/tasks were approached is outlined further in Section 2.

1.4 Glossary of Terms and Acronyms

1.4.1 Glossary of Terms

Developer – An offshore wind developer is the owner and operator of an offshore wind farm. Generally, they are large multi-national energy producers and responsible for the delivery of the project in alignment with an agreed Power Purchase Agreement (PPA).

OEM – Original Equipment Manufacturer is a company that purchase parts from other manufacturers or suppliers and use them to assemble their finished products. In the context of this report the Wind Turbine Generator (Nacelle and Blades) providers are referred to as OEMs. OEMs are considered a Tier 1 contractor, see below.

Tier 1 – Considered the main suppliers of equipment or services to the project and generally contract directly with the Developer. Contracts are typically worth tens or hundreds of millions for the top level (tier 1) packages such as Wind Turbine Generator (WTG) supply/install or Balance of Plant (BoP) supply/install. Generally, the Tier 1 contractor will take the risk for schedule and cost overrun and be penalized accordingly should they not comply with agreed delivery dates etc.

Tier 2/3 – Tier 2 and 3 contractors supply directly to the Tier 1 contractors. These are likely to provide a more bespoke or specific component or service such as turbine towers, secondary steel, cable protection systems or electrical equipment for example.

Tier 1s will have Tier 2/3s from which they exclusively source certain material/equipment/services (to guarantee price and schedule certainty) however, often, they will issue a competitive tender process to encourage competition in the supply chain. It is anticipated that Tier 2/3 contracts represent the best opportunity for the MA supply chain to enter the industry with a focus on maximizing their primary services, in order to gain experience before expanding into further areas of interest.

1.4.2 Acronyms

Acronym	Definition
AUV	Autonomous Underwater Vehicle
AWEA	American Wind Energy Association
BCC	Bristol Community College
BNOW	Business Network for Offshore Wind
BoP	Balance of Plant
CEC	Clean Energy Center
CTV	Crew Transfer Vessel
EHS	Environment Health and Safety
EPC	Engineering, Procurement, Construction
EPCI	Engineering, Procurement, Construction and Installation
FID	Final Investment Decision
FTE	Full Time Equivalent
GIS	Geographic Information System
GWO	Global Wind Organization

Acronym	Definition
HSE	Health Safety and Environment
IAC	Inter-Array Cables
IBEW	International Brotherhood of Electrical Workers
ISO	International Organization of Standardization
NYSERDA	New York State Energy Research and Development Authority
OEM	Original Equipment Manufacturer
OSW	Offshore Wind
PLA	Project Labor Agreement
PPA	Power Purchase Agreement
PPE	Personal Protective Equipment
RFI	Request for Information
RFQ	Request for Quotation
ROV	Remotely Operated Vehicle
SCADA	Supervisory Control and Data Acquisition
WTG	Wind Turbine Generator

2 APPROACH

2.1 Task A Scoping the Supply Chain

The delivery of this report was contingent upon the completion of the one of four key features referred to as Task A in a list of Tasks A-D in the Introduction of this report. Task A focused on scoping the offshore wind supply chain requirements of southern New England, through desk-based research, as well as direct interviews with key players in the offshore wind supply chain, such as offshore wind Developers and Tier 1 suppliers.

As part of our review, a comprehensive evaluation of MassCEC's Offshore Wind Supply Chain Directory (http://directory.masscec.com/listing/) was undertaken to gain a deep understanding of the offshore wind supply chain landscape in MA to date. The directory is a well-maintained repository of companies that are interested in becoming a part of the OSW supply chain in the Commonwealth of MA. It is not required for your business to be in MA in order to be listed in the directory, however, for the purposes of this report, only companies located within MA were investigated.

The assessment focused upon cataloging the MA businesses by industry sector and subsequent capabilities related to each industry sector, as defined by MassCEC. From there, Xodus compiled an industry sector taxonomy of our own, based on our expertise and experience in the OSW industry in Europe. We then bridged the taxonomies of MassCEC's directory and our internal taxonomic breakdown to show how we at Xodus would advertise the companies in the directory to our various European contacts, whether they be Developers, OEMs or Tier 1 suppliers looking to utilize MA OSW supply chain.

With the agreed taxonomy as a baseline, several interviews were held with various Developers, OEMs and Tier 1 suppliers to gain a sense of their views on several topics. These topics included:

- How far their reach extends into the OSW supply chain;
- How they define different packages that they put out for tender;
- What requirements and certifications are required to become a preferred supplier;
- Challenges associated with achieving high levels of local content;
- The impact of Project Labor Agreements and the utilization of union labor;
- How they perceive the assets and the OSW supply chain in MA;
- How the OSW supply chain and assets in MA compare to other states;
- Where should MA and its supply chain be focusing its efforts/investments.

Two templates of questions asked of both Developers and Tier 1 suppliers respectively, can be found in the Appendices to this report. Similarly, the detailed notes that were taken during each of these interviews may also be found in the Appendices.

The following companies (in alphabetical order) were interviewed to understand their needs and requirements in servicing and accessing the US offshore wind industry:

- Bladt Industries
- Equinor
- GE Renewable Energy
- JDR Cable Systems
- Mayflower Wind
- MHI Vestas
- Seaway 7
- Semco Maritime
- Siemens Gamesa RE
- Ventower Industries
- Vineyard Wind

Key takeaways from these interviews were used in parallel with the information gathered from the MassCEC Supply Chain Directory to complete Task A, which is outlined below with three primary action items, that were transformed into the subsequent sections within this report.

A. Scoping the supply chain requirements:

- Conduct interviews with all Developer teams and Tier 1 suppliers
- Articulate supply chain landscape required for Offshore Wind Development
- Define Developer and Supplier contracting process

2.2 Task B Identifying and assessing key sectors/sub-sectors

Task B of this project was intended to "assess the capabilities, qualifications, and interest of companies in Massachusetts to meet the articulated needs and requirements of the offshore wind industry."

To conduct this assessment, BW Research conducted a survey of Massachusetts firms known to be interested in participating in the offshore wind (OSW) industry, as well as Massachusetts firms that operate in industries necessary for the offshore wind supply chain.

The survey sought to assess four key components of each firm:

- Technical capabilities to provide or produce a required service/component,
- Volumetric capabilities to meet expected regional demand increases for such services/components,
- Level of interest in participating in the offshore wind supply chain, and
- Any reported engagement with the offshore wind industry to date.

Two-hundred fifty-one (251) unique firms completed the survey between December 7, 2020 and January 2, 2021.

The survey was supplemented by 11 executive interviews that sought to better understand firms' experiences and challenges in entering the offshore wind industry.

Survey respondents were asked to identify the industry sectors they participate in, among the 12 defined in the supply chain taxonomy (Phase I of this project and consistent with the Supply Chain Directory). As most firms – 63 percent of

respondents – operate across multiple sectors, the survey respondents were asked to select the single *primary* industry sector their firm operates within. Non-respondents were assigned a primary industry sector based on available information.

An additional 241 firms did not complete the survey but have previously expressed interest in participating in the offshore wind industry. Those firms – henceforth referred to as "non-respondents" – are included in industry counts (e.g. employment, primary sector, and location). These firms were primarily amassed through existing supply chain directories hosted by MassCEC and the Business Network for Offshore Wind.

For the purposes of this report the 12 primary industry sectors are organized into the following categories:

I. Construction and Operations
    1. Construction, Installation, and Operations/Maintenance Services
II. Primary Supply Chain
    2. Manufacturing and Fabrication Services
    3. Wind Original Equipment Manufacturing (OEM)
III. Secondary Supply Chain
    4. Marine Facilities, Transport, Logistics, and Safety
    5. Equipment, Supplies, Materials, and Associated Services
IV. Development and Professional Services
    6. Environmental, Engineering, Geological, & Testing Services
    7. Professional and Consulting Services
    8. Wind Project Development
V. Support Services
    9. Government
    10. Trades, Labor, and Workforce Organization
    11. Education/Training
    12. Other

Key supply chain sectors – namely, Manufacturing and Fabrication Services; Marine Facilities, Transport, Logistics, and Safety; and Original Equipment Manufacturing (OEM) – were examined in greatest detail.

The next phase of the project will use these results, in combination with Phase I research, to "assess the overall strengths and gaps in the ability of Massachusetts companies to meet offshore wind industry supply chain needs."

2.3 Task C Analyzing strengths and limitations of MA and comparing to neighboring states

2.3.1 Post-Survey Database Analysis

An analysis was conducted to show the changes in the contents of the MassCEC Supply Chain Database from the time the first draft report was issued (November 2020) until now (March 2021). The efforts that were undertaken in this report were supplemented by work conducted by BW Research, who administered a survey to hundreds of companies around Massachusetts to gauge their interest and capability of becoming a part of the offshore wind supply chain. As a part of the survey, it was strongly encouraged for companies that participated to enroll in the MassCEC database.

Upon the completion of the survey, an itemized list of companies that were identified and contacted by BW Research was used to map companies that registered themselves in the database after completing the survey, as well as to make predictions as to the number of companies likely to be present in each industry sector based on the responses that were received. It is important to note that not every company that completed the survey enrolled in the database, and that companies that were not contacted as part of the survey enrolled in the database between November 2020 and March of 2021.

Multiple charts were generated in this analysis to give an illustration of the contents of the MassCEC as it stood in November 2020, where it currently stands in March of 2021, and the projected number of companies in each industry sector based on the respondents to the BW Research survey. These charts give a glimpse into the strengths and gaps of the offshore wind supply chain in MA, which were more clearly defined and explained as a result of the MA Supply Chain Opportunity Analysis outlined in Section 2.2.

2.3.2 MA Supply Chain Opportunity Analysis

The contents of the MassCEC Supply Chain Directory were mapped against the Xodus supply chain taxonomy and analyzed to identify supply chain sectors where Massachusetts companies are well positioned to meet, or adapt to meet, the offshore wind industry's requirements. Companies identified through the work in Phase 2 that are not currently in the Supply Chain Directory were also considered. The analysis of MA and neighboring state supply chain opportunity was carried out using a consistent set of criteria applied to each supply chain element:

- Experience in offshore wind: The number of companies in-state who have supplied to the offshore wind sector, either in the US or elsewhere in the world;
- Experience in adjacent industries: The strength and applicability of supply chain expertise in state supplying relevant adjacent industries, such as the marine and energy sectors;
- Market volume resilience: How much the success of supply chain companies will depend on the volume of installed offshore wind project capacity;

- Advantage for local supply: The nature of any competitive advantage for supply from in-state, considering possible logistics benefit or existing supply chain strength;
- Opportunity for export supply: The potential for in-state companies to supply projects down the US east coast or beyond, should capability be established;
- Relative project spend on supply area: Proportion of total lifetime project spend typically attributable to the supply chain category; and
- Investment case: Level of investment and market confidence needed to develop supply chain capability.

A scoring system was applied to each criterion as described in Table 2-1.

Table 2-1 Scoring system for opportunity analysis

CRITERION	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Experience in offshore wind	No local companies with experience in offshore wind.	Local companies have no offshore wind experience but are known to be actively pursuing opportunities.	Up to two local companies with offshore wind experience.	More than two local companies with offshore wind experience.
Experience in adjacent industries	No known local companies with relevant experience in an adjacent industry.	Local companies with some relevant experience but are unlikely to offer a competitive solution in offshore wind.	Local companies with some relevant experience that may need some change in strategy or additional investment to support supply to offshore wind projects.	Local companies with some relevant experience and are likely to supply in offshore wind with minimal change in strategy or additional investment.
Market volume resilience	Local companies' success is likely to depend almost entirely on orders from the offshore wind sector.	Local companies' success is likely to depend on >50% of order book from the offshore wind sector.	Local companies' success is likely to depend on <50% of order book from the offshore wind sector.	Local companies' success can be independent of orders from the offshore wind sector.

CRITERION	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Advantage for local supply	No competitive advantage to local suppliers from either existing local supply capability or logistics benefit.	Minor competitive advantage to local suppliers, either from existing local supply capability or logistics benefit.	Competitive advantage to local suppliers, either from strong local supply capability or significant logistics benefit.	Competitive advantage to local suppliers from both strong local company experience and significant logistics benefit.
Opportunity for export supply	Significant logistics barrier to non-local supply or established competing supply harms export opportunity.	Some logistics benefit to local supply or established competing supply limits export opportunity.	No particular logistics benefit to supply or lack of established competing supply means non-local suppliers are not disadvantaged.	No particular logistics benefit to supply and lack of established competing supply means non-local suppliers will be required on nearby export projects.
Relative project spend on supply area	Spend in this area is <1% of project lifetime expenditure.	Spend in this area is between 1% and 1.5% of project lifetime expenditure.	Spend in this area is between 1.5% and 5% of project lifetime expenditure.	Spend in this area is >5% of project lifetime expenditure.
Investment case	Investment required to supply is significant enough to need public support and requires long-term confidence in offshore wind market.	Investment required to enable supply triggered by long-term confidence in offshore wind market.	Investment required to enable supply can be triggered by single offshore wind contract.	Little or no further investment needed to enable supply.

2.4 Recommendations

Based on the information, assessment, and results of the three previously completed project phases, and informed by virtual workshop sessions between members of Xodus Group, BW Research and MassCEC, a set of 18 recommendations were developed for Massachusetts offshore wind supply chain development.

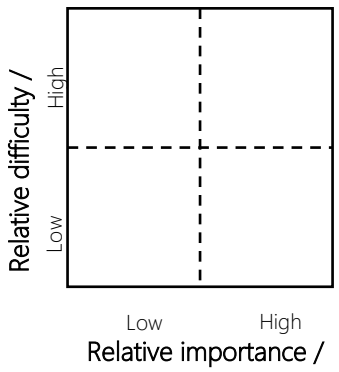
In these sessions, several thematic areas for recommendations were introduced:

- Market development
- Investment
- Workforce
- Innovation
- Policy

Recommendations were formulated, discussed, and categorized according to thematic area to show how various ideas could be developed to improve and bolster Massachusetts' position within the offshore wind industry.

The recommendations for each thematic area were then transposed onto a matrix used to discern the associated relative difficultly and/or cost in addition to the relative importance and/or impact that implementing the recommendations would have. Considering in which quadrant recommendations fell on the impact-difficulty matrix enabled further characterization of their type according to four broad designations:

1. Lower difficulty/Lower Impact - Relatively straightforward to execute but somewhat limited consequence/outcomes. This group of recommendations is not urgent to implement but could be advanced opportunistically.
2. Higher difficulty/Lower impact - Complex/difficult to execute but somewhat limited consequence/outcomes. Recommendations in this group would benefit from further evaluation to assess cost/benefits.
3. Lower difficulty/Higher impact - Relatively straightforward to execute; should result in important consequence/outcomes. This group should be considered as higher priority.
4. Higher difficulty/Higher impact - Recommendations in this group are complex and/or challenging to execute; these should result in important consequence/outcomes. Recommendations in this group will benefit from strategic planning, coordination, and cost-sharing.



3 TASK A – INTERVIEW OVERVIEW

3.1 Developers/Owner Operators

The owner operators expressed a wide range of views on their approach the OSW market, the MA supply chain and how the state could best support OSW growth. Common elements were identified in all discussions and these will be helpful in developing recommendations on how best to utilize MassCEC investment and human capital. The common themes are:

- Project timing greatly influences supply chain development;
- The Tier 1s have a greater influence on the supply chain;
- The supply chain is immature due to project implementation;
- A cluster strategy would be advantageous.

3.1.1 Project Timing and Supply Chain Development

The depth of knowledge around the MA supply chain is in direct correlation to the timing of project delivery. The companies with the most imminent projects have greater knowledge of the MA supply chain and its strengths and weaknesses. As developer projects move further out, supply chain knowledge becomes less specific and more anecdotal. What is clear in all cases is that much of the supply chain development and knowledge was pushed to the Tier 1s for their development. The developers concentrate on their tier ones.

As there are no scale projects currently constructed in MA, the developers use traditional package development as implemented in European projects (i.e. WTG, foundations, cables, substations) as a basis for Requests for Proposals (RFPs) but they are required to also create individual contracts for services such as installation as the supply chain is not developed to a point where EPC or EPCI contracts are viable. It is the desire of the developers to have EPC contracts and all felt these will be the norm in the future, but it will require the supply chain to (a) gain experience and (b) the pipeline of projects to grow. The developers are using a hybrid model for the early projects and will in some cases divide packages based upon common components and work to accommodate the available local supply chain.

1.1.1 Supply Chain Influence by Developers

The influence developers have on Tier 1s and their suppliers is minimal as the developer's concern is cost and project delivery which lies with the Tier 1s. It is their suppliers' job to meet project requirements. For certain critical pieces, the developers may ask for a supplier list for key component partners, but this is not always the case. In general, the developers believe the key relationships with the local supply chain need to be developed and managed by the Tier 1s. In the initial projects the bulk of work will be imported from Europe by the tier ones, but as future projects ramp, there will an increase in local content.

The criteria the developers use for evaluating suppliers is dependent upon the Power Purchase agreement (PPA). If it is a price driven PPA, cost is the driving factor, if its local content then supply chain plays a greater role. A developer clearly stated that in local content heavy PPAs, the Tier 1s are rated upon their ability to incorporate the local supply chain in its response to RFPs. A common and highly important selection criteria expressed by all developers is HSE. An adherence to diversity and ethical standards also is important. Financial strength receives much weight in the internal evaluation of Tier 1s.

3.1.2 Supply Chain Maturity

When looking at the local MA supply chain the developers expressed the lack of experience in offshore projects means the supply chain is, in general, unproven and therefore lacks in maturity. This is not to say it is inadequate, just untested. The time frames of contract execution and product delivery creates problems. The supply chain is unaccustomed to the long periods between engagement and revenue. As this can take two or more years most supply chain company business models are not consistent with OSW delivery. To keep the supply chain engaged is a challenge.

As mentioned above, Project Labor Agreements (PLAs) do play a major role in the developer's plans and modelling based upon PPA criteria, but the extent is dependent upon where they are in the process. The closer to delivery, the more important PLAs become as RFPs and quotes are being generated. Most developers are involved in the negotiations and the results are pushed to their Tier 1s for inclusion in RFPs, bids and responses. The developers, to date, have not included the Tier 1 suppliers in the PLA process but it is believed there is the intention to do so.

3.1.3 Training and Workforce Development

A key strength of the MA supply chain is the delivery of training programs both specifically for wind such as GWO and skills training to develop an OSW workforce. It is important to coordinate this training with project timing to ensure the workforce is available at the required time and that those going through the training have job opportunities upon completion.

Training needs to follow project timelines. This ties into the opinion that the developers perceive there is an adequate skilled labor in the state, and more will be available as required. In preconstruction work (environmental, permitting, etc.) the developers have found the workforce and supply chain very good. By all interviewees the high concentration of college graduates gives MA a significant advantage in executive, science and engineering talent.

The developers see there are many industries in the state where the work and skill sets are transferable to OSW, further bolstering the availability of a trained workforce. A key to Massachusetts' continued success in building a supply chain will be ports and their creative use. If there are improvements and investments in physical assets such as a port, more companies and workers will be attracted. All viewed The Port of New Bedford as a key asset in building the supply chain. The strength of the MA supply chain will become more evident over time as projects move ahead and there will be direct involvement from the local supply chain.

3.1.4 Massachusetts Efforts and Focus

The efforts put towards the development of the MA supply chain should continue to be focused on infrastructure development including ports (Brayton Point was mentioned several times). It will also be important to get an Tier 1 to establish a production operation in the state. This will create a supply chain and promote confidence in the industry in MA. The work done on the compilation of the MA supply chain directory is a good start, but a further layer of qualification is needed to make the directory of greater value.

Matchmaking events were described as beneficial in the development of the supply chain as communication of expectations, timing and scope are viewed as critical elements to success. These are very important between Tier 1s and the local supply chain, but developers should be present to delineate overall project needs and time frames.

It is important for MA to look at a cluster strategy, perhaps with other states, to develop a specific expertise (O&M and laydown were mentioned several times). There should be investments around the cluster to insure it is successful in growing the industry. MA is ahead of other states in its OSW programs and understands the need of the industry better than most. There is competition form NY/NJ and Virginia which is why a cluster strategy will ensure success as the state will be able to differentiate itself.

3.2 Tier 1 Contractors

The Tier 1 contractors (Tier 1s) interviewed had similar views to the developers on the state of the Massachusetts supply chain. They are more involved (and invested) in the broader supply chain and as a result were more specific in their evaluation and comments. In all cases, they felt their supply chain interactions were driven by their own business and in only limited cases were influenced by the developers or introduced to potential supply chain partners by the developers. Common themes in the interviews were:

- There are three critical success factors:
  - (1) Current market conditions;
  - (2) Potential market opportunities;
  - (3) Market predictability.
- The supply chain is immature and untested;
- Project timelines are a challenge for the supply chain.

3.2.1 Project Timing and Package Delineation

The supply chain is project based at this time and will hopefully grow to market based once actual work begins. Project delivery time frames coupled with component complexity have the greatest effect on supply chain development. It is important to note that initial project approval and start will spread confidence within the Tier 1s that the industry is real and establishing a US supply chain is critical to meet price goals and timing goals. As it stands, there are no approved projects, so the Tier 1s are working on supply chain networking in anticipation of market growth and predictability.

The Tier 1s have defined packages that are transferred from their European experience. These packages allow the Tier 1s to deliver very specific requirements to the supply chain which they find as an easier means to evaluate supply chain competencies. These packages can vary project to project based upon implementation timeframes and supply chain depth. For any given project, the Tier 1s may have as many as 50 contracts in support of a project, so supply chain reliability is of paramount importance. Due to the time it takes to onboard a supplier, the initial project(s) will rely heavily on companies already in the Tier 1s supply chain. This is especially true for major components. The result will be early projects will be supported from established locations and delivered to MA.

3.2.2 Local Supply Chain Maturity and Timing

All Tier 1s want to have a local supply chain and are actively pursuing relationships. There is a universal concern that the supply chain has not embraced the time between identification and actual revenue. Depending upon the complexity and criticality of the component, just the acceptance into the Tier 1s supply chain can take two years, with realized revenue only being accrued two years beyond this point. This points to the cost, both financial and resource, that may be required to become a preferred supplier. This process is not common in US industries. The Tier 1s realize that communication is critical to their success. However, it is important for these Tier 1s and the enablers to understand it is not only communication of opportunity, but also of timing, process and risk which are key engagement and success.

The Tier 1s, while mostly following traditional packages seen in Europe, are also flexible to local contract terms. In some contracts it is the Tier 1s responsibility to provide installation or O&M solutions where in others these may be controlled by the developer. As the market opportunity increases, standardized US packages will emerge that will increasingly rely on a local supply chain.

3.2.3 Developer Influence on Tier 1 Supply Chain

The selection of supply chain partners in general is not influenced by the developers. There are exceptions to this for the most complex or critical components. As observed in the developer interviews, Tier 1s may need to identify or use tier two suppliers recommended by the developer. In most cases, the project requirements are pushed from the developers to the tier one suppliers and the tier one suppliers need to find suitable partners. As the tier one suppliers are not going to operate multiple manufacturing operations, there are two levels of supply chain critical for success: one in support of a project and one in support of a central operation. Supply chain analysis is therefore taking two distinct paths. This points to the importance of having a local manufacturing operation that will grow both the project and industry supply chain.

Local content does not play a major role in most Tier 1s decisions. Local content is to be dealt with by the developers. The Tier 1s will find the highest quality at the best price. There are advantages to having components and work done locally as it reduces costs and allows for more on-site involvement, but it is not the PPA local content requirements that drive the decision.

3.2.4 Tier 1 Role in Supply Chain Development

The evaluation of supply chain partners is a well-documented process that emanates from the European market. The most critical elements in the evaluation process are; ability to comply and meet industry standards, ability to comply and meet internal Tier 1 standards, financial stability, ability to scale and a desire to assume risk due to long lead times.

The Tier 1s are very open to sharing specifications, drawings, standards requirements and any other data sets that will help the supplier meet necessary standards. It is important to note that this work begins once the potential partner is identified. The challenge is getting introduced to the partners. The Tier 1s reported that finding local partners is difficult. The Tier 1s need to find the partners themselves and rely on published data bases, state economic development agencies and word of mouth. The published databases may be of some value initially, but it would be far more helpful for a state or region to develop prequalified suppliers based on Tier 1 requirements. The Tier 1s would welcome active participation in such a program. All reported that they are open to and consider critical, clarification meetings with suppliers at the outset to insure mutual understanding of the process.

Supply chain engagement begins far in advance of the project. The Tier 1s need confidence that the supply chain partners selected will be able to meet project goals and established timelines as delays, especially in key components, are very costly and can have an exponential effect on project outcomes. Critical is a clear understanding of the engagement process to maintain dialogue and jointly develop a process of engagement. The Tier 1s also make very clear the financial commitments expected from the supply chain partner. All this work needs to be done in advance of an RFI or RFQ, as the Tier 1 does not have time to develop relationships at the time of these documents. At RFI or RFQ stage, the supply chain network needs to be in place.

3.2.5 Massachusetts Strengths

In discussing the MA supply chain, The Port of New Bedford and a strong labor force were consistently cited as key strengths of MA. The state has done a very good job in communicating the available supply chain to Tier 1s. As there are no projects in the water, the supply chain is untested, and this is viewed as a risk factor by the Tier 1s. In addition, early projects will not heavily utilize the MA supply chain, but supply chain utilization will increase as the volume of projects increase. There is huge potential, but it is not immediate. This is due to the Tier 1s relying in their existing and established partners for early projects as they do not have manufacturing operations established in the US. Most packages will be delivered complete with limited involvement locally. This is a model that cannot be sustained over time and there is an urgency in creating a local supply chain.

The existing supply chain for environmental and engineering is very strong and due to the university concentration is expected to continually be strong. This is a real advantage to MA and of keen interest to may Tier 1s. Many interviewed thought a regional cluster strategy would work well. The cluster strategy should be built on current assets. The ability to recruit offshore construction is difficult but the Tier 1s are looking to construction firms that may have transferable skills to the offshore market. This will require extensive training but over time this should fill the gap.

The NY/NJ area was cited as an attractive manufacturing location for the Tier 1s due to the available land, skilled workforce and proximity to the lease areas. MA however was viewed as second or third overall in the Northeast.

3.2.6 Massachusetts Efforts and Focus

The Tier 1s reported that the most effective work to grow the supply chain in MA is to continue communicating supply chain assets to the Tier 1s and developing matchmaking programs to build the relationships. This needs to be done early in the development process and should come from a refinement of databases of supply chain partners. The information as it exists does not provide a level of detail meaningful to Tier 1s.

Local incentives should be used to aid in the development of a Tier 1 manufacturing location. There is no better means to build a supply chain than around a large manufacturer. This would also send a message that MA is fully committed to OSW and its industrial development. A continuation of skilled labor development is also an area of focus. Timing of training with supplier need is important and there should be flexibility in the training to react to project timing. This something MA has done very well.

4 TASK A - TAXONOMY BREAKDOWN

4.1 Massachusetts Clean Energy Center Taxonomy

The MassCEC has put together a directory of companies located throughout the United States and around the world that have expressed interest in becoming a part of the offshore wind supply chain in the Commonwealth of MA. The companies in this directory are organized both based on their relevance to different offshore wind industry sectors, as well as through further sub-classifications of the competencies of each company. For the purposes of this report, only the companies located within MA were investigated. To summarize how many companies were listed in the directory, at the time of this report, a chart was created in Figure 4-1 to show the number of companies listed within each industry sector.

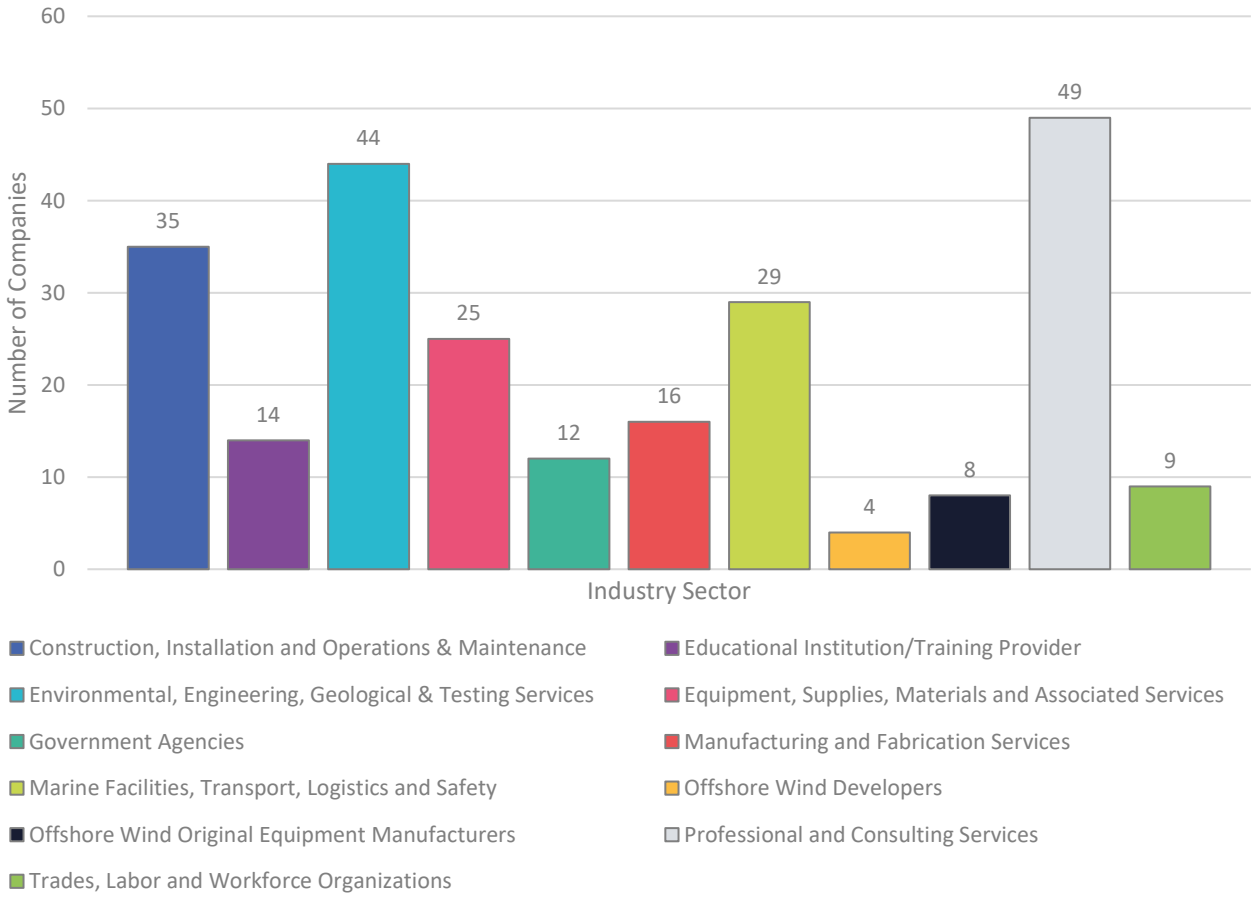


Figure 4-1 MassCEC Directory Summary of Industry Sectors

4.1.1 Construction, Installation and Operations & Maintenance

The first industry sector that is present in the MassCEC Directory relates to Construction, Installation and Operations & Maintenance activity. A total of 35 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-1.

Table 4-1 Number of Massachusetts Companies in MassCEC Directory with Capability in Construction, Installation and O&M

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Construction, Installation and Operations & Maintenance	**Construction and Logistics Management**	**12**
	Crane Lift Operations	**6**
	Diving	**4**
	Dredging	**6**
	Electrical and Cable Installation	**8**
	Electrical Services	**5**
	Engineering Procurement, Construction and Installation (EPCI)	**13**
	Jacket Installation	**1**
	Land-Based Construction	**11**
	Marine Construction	**14**
	Mechanical Services	**4**
	Monopile and Transition Piece Installation	**3**
	Pile Driving	**5**
	Pre-Assembly	**5**
	Site Development and Excavation	**7**
	Wind Turbine Generator Installation	**4**

As shown in Figure 4-2 the strongest supply chain presence appears to be in construction companies (with the 4 highest competency areas all on this theme), with marine construction the area best represented by MA companies. This is not surprising given that these capabilities are not exclusive to OSW, however, capability of these companies requires further investigation to identify their readiness to supply to OSW projects. Additionally, there is an apparent representation of companies with the capabilities to offer services generally bespoke to OSW installation (including: WTG, monopile, TP and Jacket installation). This is unexpected given the lack of OSW projects that have been installed in the US market to date for native MA suppliers to have built track record or for non-US suppliers to have established a base in MA.

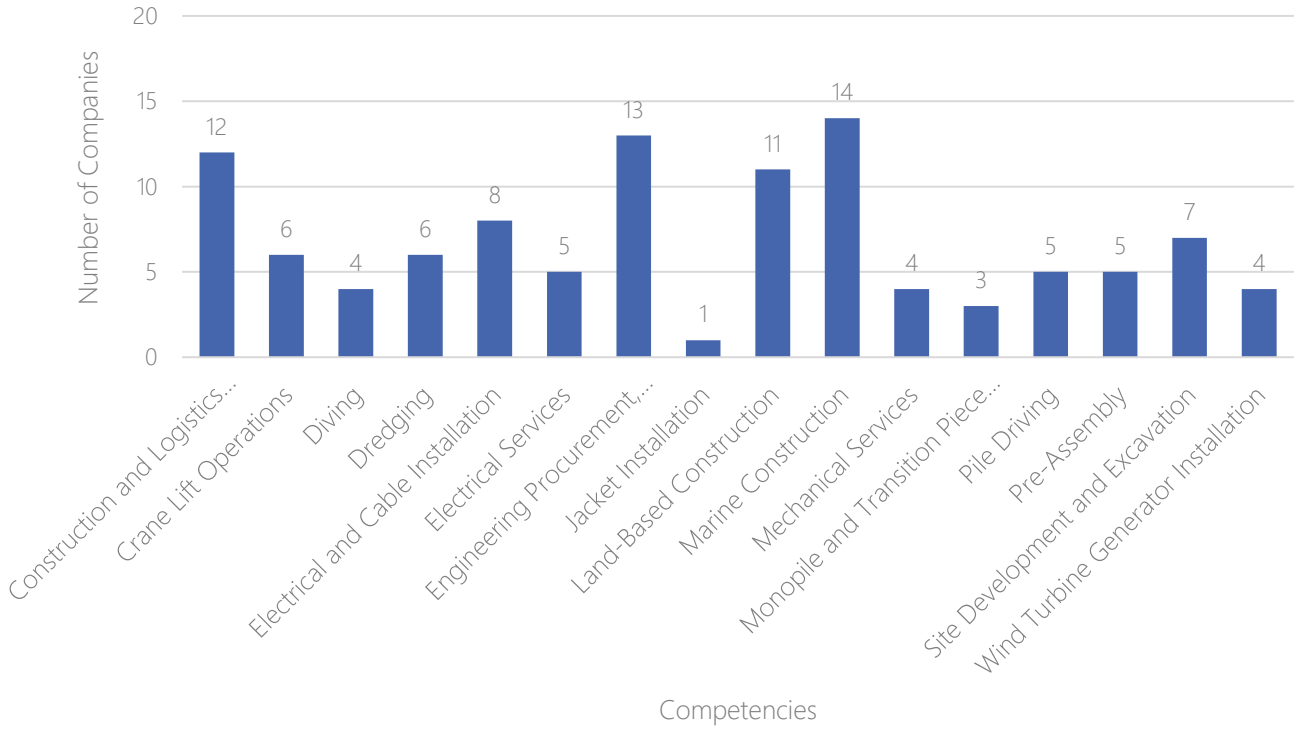


Figure 4-2 MassCEC Directory: Construction, Installation and O&M Sector Breakdown

4.1.2 Educational Institution / Training Provider

The second industry sector that is present in the MassCEC Directory relates to Educational Institution / Training Providers. A total of 14 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in

MA has a strong educational community, and this is represented through the number of companies listed across multiple competencies. It was noted during supply chain engagement that training of skilled workforce to be a potential barrier to enabling local content, but the raw data suggest these facilities are available. In the next phase of the project it will be important to understand the strengths of competency providers further to determine if there is a capability gap or if it is a case of the services are not been sufficiently communicated.

Table 4-2 Number of Massachusetts Companies in MassCEC Directory with Capability as Educational Institution/Training Provider

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Educational Institution/ Training Provider	**College Degree Programs**	**7**
	Health, Safety and Environmental Training	**8**
	K-12 Curriculum and Instruction	**1**
	Skilled Trades (Mechanical, Electrical, Hydraulics, Welding)	**2**
	Vocational High School	**0**
	Workforce and Skilled Trades Training	**8**

MA has a strong educational community, and this is represented through the number of companies listed across multiple competencies. It was noted during supply chain engagement that training of skilled workforce to be a potential barrier to enabling local content, but the raw data suggest these facilities are available. In the next phase of the project it will be important to understand the strengths of competency providers further to determine if there is a capability gap or if it is a case of the services are not been sufficiently communicated.

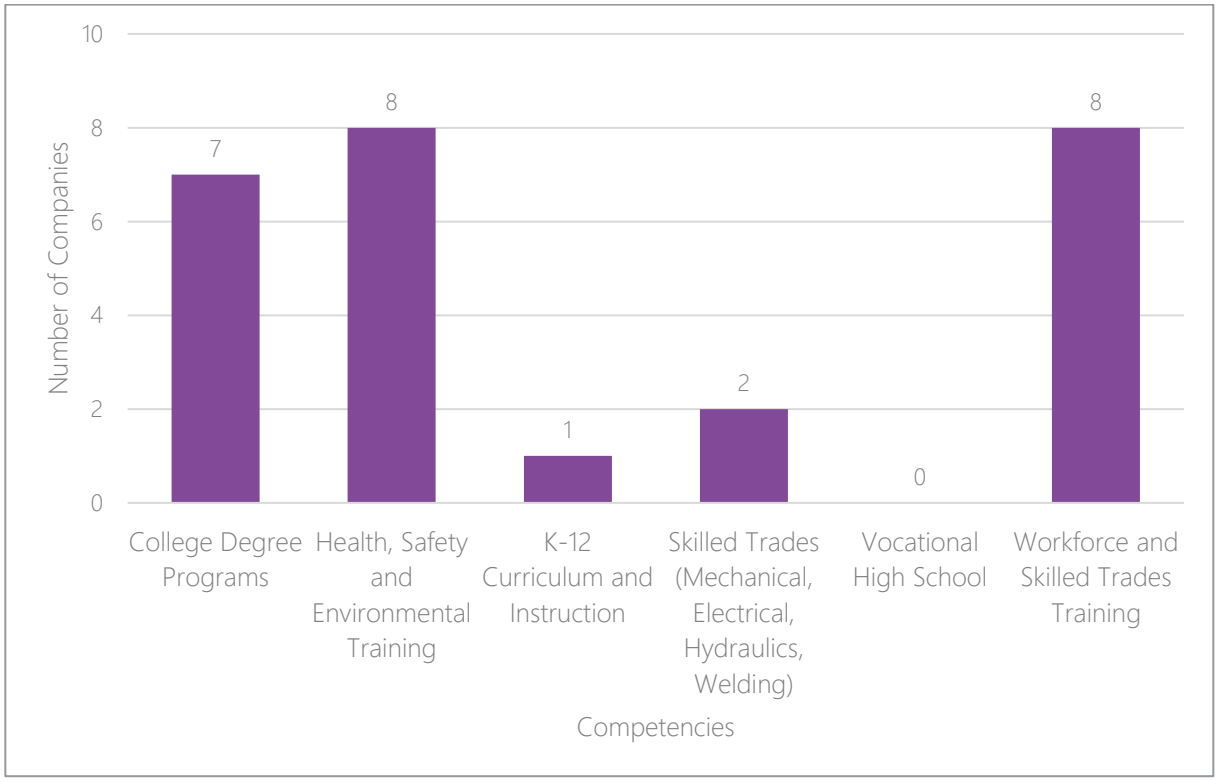


Figure 4-3 MassCEC Directory: Educational Institution/Training Provider Sector Breakdown

4.1.3 Environmental, Engineering, Geological & Testing Services

The third industry sector that is present in the MassCEC Directory relates to Environmental, Engineering, Geological & Testing Services. A total of 44 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-3.

Table 4-3 Number of Massachusetts Companies in MassCEC Directory with Capability in Environmental, Engineering, Geological and Testing Services

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Environmental, Engineering, Geological & Testing Services	**Biological and Marine Life Surveys and Studies**	**11**
	Engineering: Civil	**28**
	Engineering: Electrical	**16**
	Engineering: Environmental	**20**
	Engineering: General	**26**
	Engineering: Structural	**21**
	Environmental Cleanup	**10**
	Environmental Permitting, Assessments, Analysis and Impact Statements/Reports	**24**
	Material Testing and Inspection	**9**
	Meteorological Data and Testing	**6**
	Ocean Geophysical Survey	**7**
	Ocean Geotechnical Survey (Soil and Core Testing)	**9**
	Physical Oceanography (Currents, Waves, Tides)	**9**
	Protected Species Observing	**10**
	Remote Sensing Services	**10**

As seen in Figure 4-4 it is evident from the raw data that MA continues to be a central hub for professional services. Supported by a nation leading education cluster the state will continue to grow and remain the gold standard resource for these services particularly Environmental Permitting, Assessments, Analysis and Impact Statements/Reports.

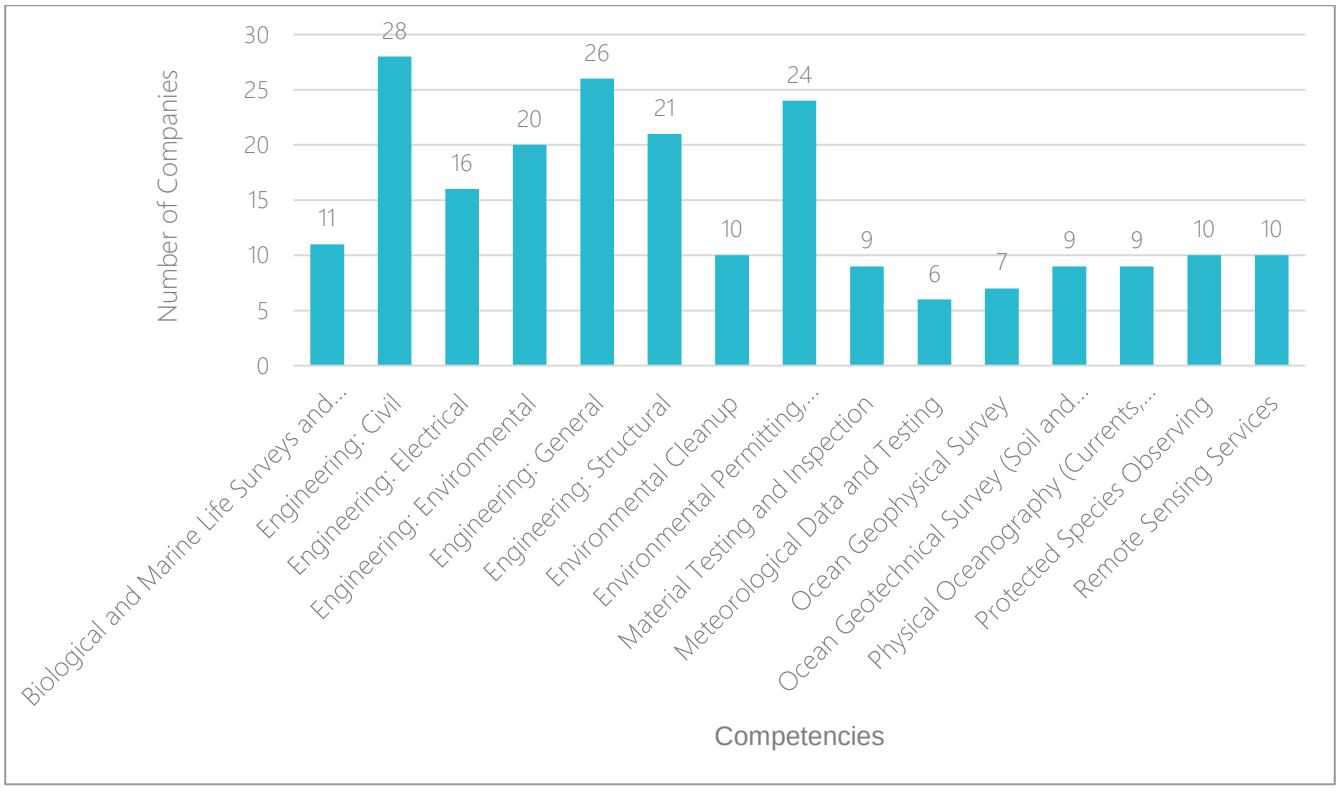


Figure 4-4 MassCEC Directory: Environmental, Engineering, Geological & Testing Services Sector Breakdown

4.1.4 Equipment, Supplies, Materials & Associated Services

The fourth industry sector that is present in the MassCEC Directory relates to Equipment, Supplies, Materials and Associated Services. A total of 25 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-4.

Table 4-4 Number of Massachusetts Companies in MassCEC Directory with Capability in Equipment, Supplies, Materials and Associated Services

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Equipment, Supplies, Materials and Associated Services	**Accommodations Provider**	**3**
	Aggregate/ Concrete	**1**
	Cables (Electrical/Telecommunications)	**1**
	Drones	**3**
	Electrical Components or Controls	**5**
	Engine/Diesel Parts	**2**
	Engine/Diesel Repairs (Non-Marine Vessels)	**0**
	Fabricated Steel Products, E. G. Decks, Platforms, Ladders and Rails	**5**
	Fasteners	**0**
	Fire Protection Materials and Services	**1**
	Forklifts and Trucks	**2**
	Fuel and Diesel	**1**
	Generators, Compressors, Portable Welders, Pumps and Motors	**1**
	Hand Tools, Power Tools and Painting Supplies	**0**
	Heavy Lift Cranes, Crawler Cranes and Modular Transport	**4**
	Lifting Appliances, Rope, Rigging and Slings	**5**

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
	Marine Horns and Lighting	**1**
	Personal Protection Equipment (PPE)	**2**
	Plastic Pipe and Fittings	**2**
	ROV, AUV, and Subsea Equipment	**3**
	SCADA and Central Monitoring Systems	**3**
	Steel Plate, Pipe or Bar	**0**
	Warehouses and Storage	**4**
	Waste and Facilities Management	**0**
	Welding Supplies	**1**

As seen in Figure 4-5 there may be room for improvement in capturing MA supply chain capability as there appears few competency areas with strong supply chain representation within this sector. Most notably there are several areas with an apparent absence of supply capability, including the provision of basic fabrication materials such as fasteners and steel plate, pipe or bar (although conversely the similar competency area of fabricated steel products appears to have the highest representation).

Experience in different ports within MA indicates that there are more companies that are capable of supplying these types of services than are represented in the directory. Increased communication to companies within this sector to inform them about listing themselves in the directory is recommended.

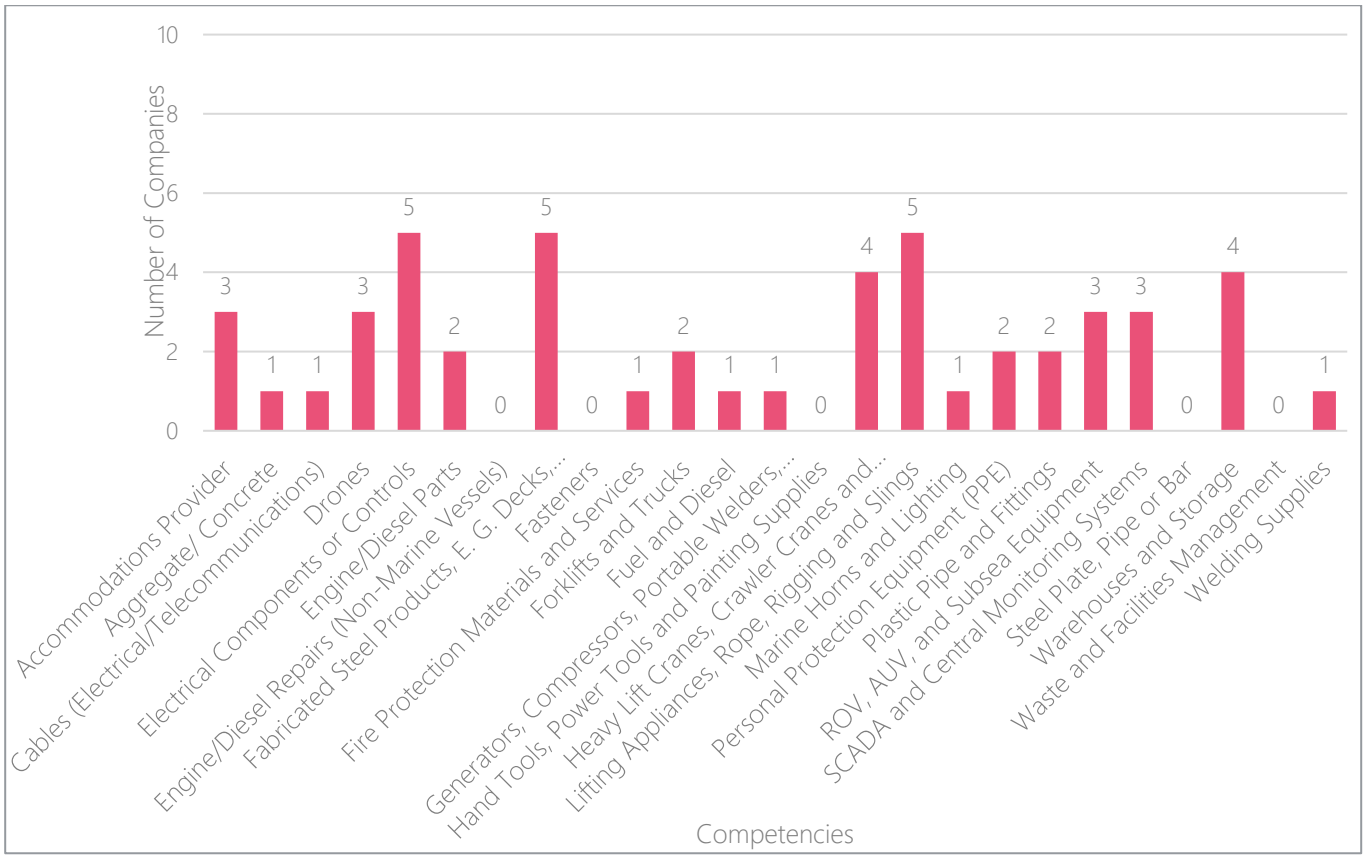


Figure 4-5 MassCEC Directory: Equipment, Supplies, Materials and Associated Services Sector Breakdown

4.1.5 Government Agencies

The fifth industry sector that is present in the MassCEC Directory relates to Government Agencies. A total of 12 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-5.

Table 4-5 Number of Massachusetts Companies in MassCEC Directory Listed as Government Agencies

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Government Agencies	**Economic Incentive Programs**	**2**
	Energy Procurement and Regulation	**3**
	Environmental Review and Permitting	**6**
	Planning and Policy	**6**
	Programmatic Support for Offshore Wind (Environmental, Fisheries)	**7**
	Workforce Development	**5**

From the data in the directory there appear to be companies in MA that can provide services for each of the pertinent competencies within this sector. However, when delving further into exactly who the companies are that are listed in this sector, it was found that they are not necessarily government agencies themselves, but rather provide the services that are listed under that designation. Including the details of government agencies relevant to the OSW sector active in MA may strengthen the directory.

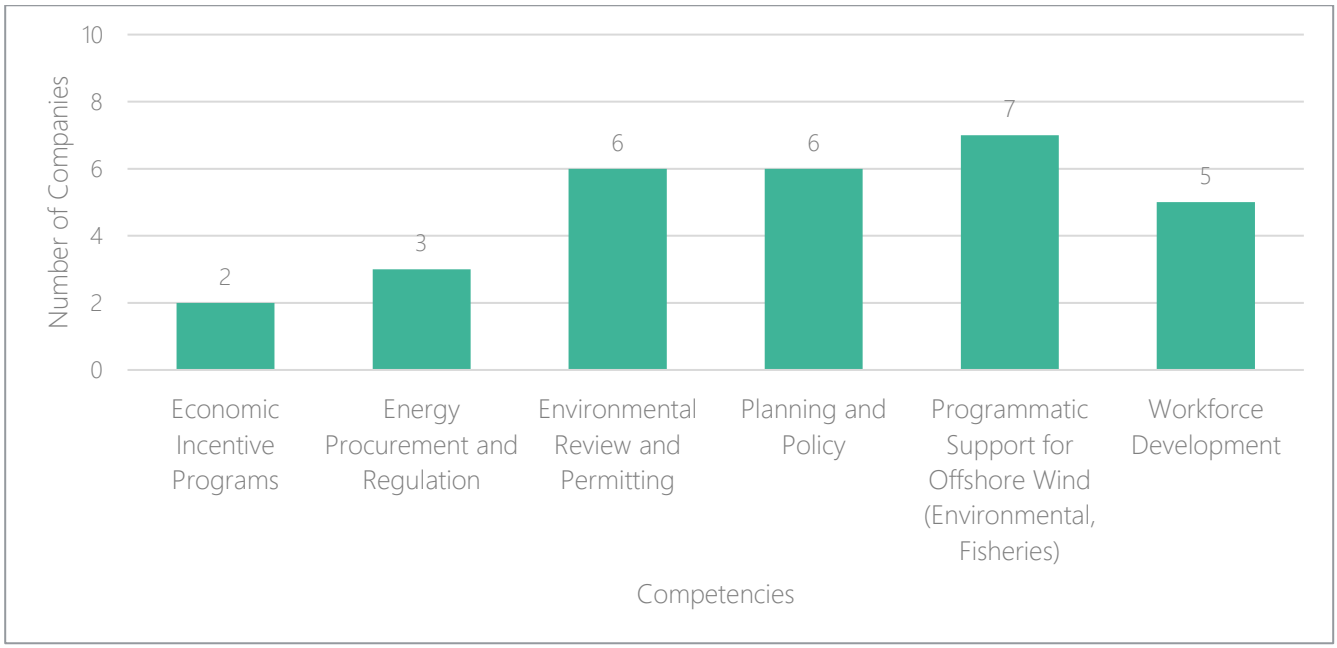


Figure 4-6 MassCEC Directory: Government Agencies Sector Breakdown

4.1.6 Manufacturing & Fabrication Services

The sixth industry sector that is present in the MassCEC Directory relates to Manufacturing & Fabrication Services. A total of 16 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-6.

Table 4-6 Number of Massachusetts Companies in MassCEC Directory with Capability in Manufacturing and Fabrication Services

INDUSTRY SECTOR	COMPETENCY	NUMBER OF LISTED COMPANIES
Manufacturing and Fabrication Services	**Blasting**	**2**
	Casting	**2**
	Coating	**2**
	Electrical Components/Electronics	**5**
	Machining	**5**
	Mechanical Components	**5**
	Milling	**5**
	Painting	**2**
	Rolling	**4**
	Welding	**8**

The current state of the directory as it relates to Manufacturing and Fabrication Services shows that the strongest representation of the MA supply chain appears to be in welding services where a total of 8 companies from MA have been listed. However, there are relatively few companies listed in these core fabrication services. The capability of listed suppliers requires further investigation to identify whether these services can be provided at the scale, volume and quality required for OSW manufacturing.

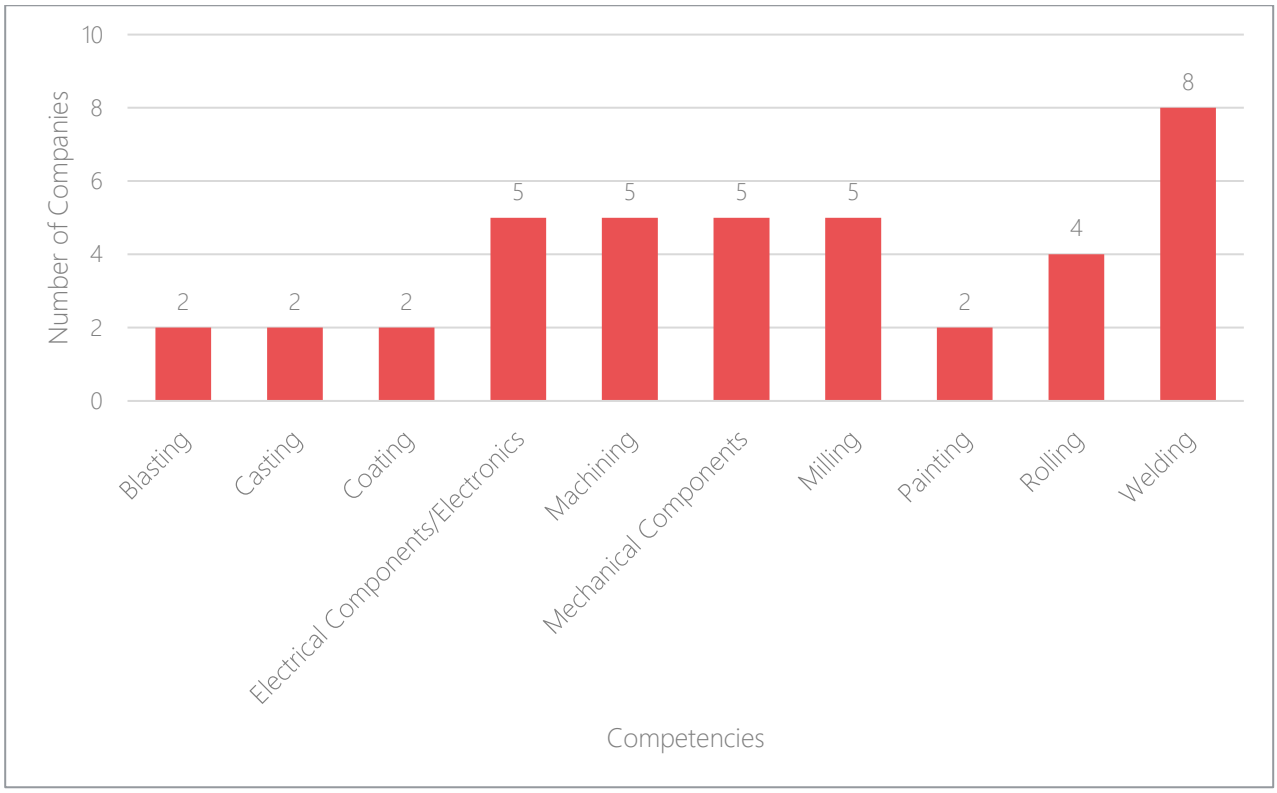


Figure 4-7 MassCEC Directory: Manufacturing and Fabrication Services Sector Breakdown

4.1.7 Marine Facilities, Transport, Logistics & Safety

The seventh industry sector that is present in the MassCEC Directory relates to Marine Facilities, Transport, Logistics & Safety. A total of 29 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-7.

Table 4-7 Number of Massachusetts Companies in MassCEC Directory with Capability in Marine Facilities, Transport, Logistics and Safety

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Marine Facilities, Transport, Logistics and Safety	**Boating Products**	**6**
	Bulk Carriers	**3**
	Crew Transport Vessels	**8**
	Customs Brokers	**0**
	Fuel and Diesel	**0**
	Helicopter Services	**0**
	Lightering	**0**
	Line Handling/ Longshoremen	**3**
	Marinas, Docking and Vessel Lay-Over	**7**
	Marine Logistics	**10**
	Marine Safety Services	**4**
	Marine Salvage	**2**
	Marine Security, Guard/Chase Vessels and Services	**4**
	Marine Surveyors	**6**
	Marine Vessel Parts	**1**
	Marine Vessel Repairs	**1**
	Marine/Shipping Terminals	**8**
	Pilots	**0**

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
	Port and Facility Security Services	**4**
	Service Operation Vessels	**6**
	Ship and Boat Building	**2**
	Stevedoring Contractors	**2**
	Tugs/Barges/Towing	**4**
	Vessel Agent	**2**
	Vessel Inspections and Compliance	**0**
	Warehouses	**4**

Figure 4-8 shows that there are a number of highly relevant OSW supply areas where the MA supply chain has strengths, such as with CTVs, Marine Logistics and Marine and Shipping Terminals. Conversely, there are also a few competencies that are listed in the directory for this sector with an apparent absence of supply. Six of the competencies list zero companies that are capable of delivering services. It is likely that some capability in these areas exists in MA so further outreach to the supply chain may be necessary.

One of the strengths indicated in the directory appears to be the provision of CTVs. While this is encouraging to see, further investigations into the capabilities and vessels that these companies offer would serve the directory well to identify whether these companies are indeed capable of supply.

Considering the established marine industry (beyond offshore energy development) in MA, it is surprising to see some of the competency categories (with exception of helicopter services) with low, or in some cases, zero attributed companies. This should be investigated in more detail in service area 2 with an aim to strengthen this area of the database.

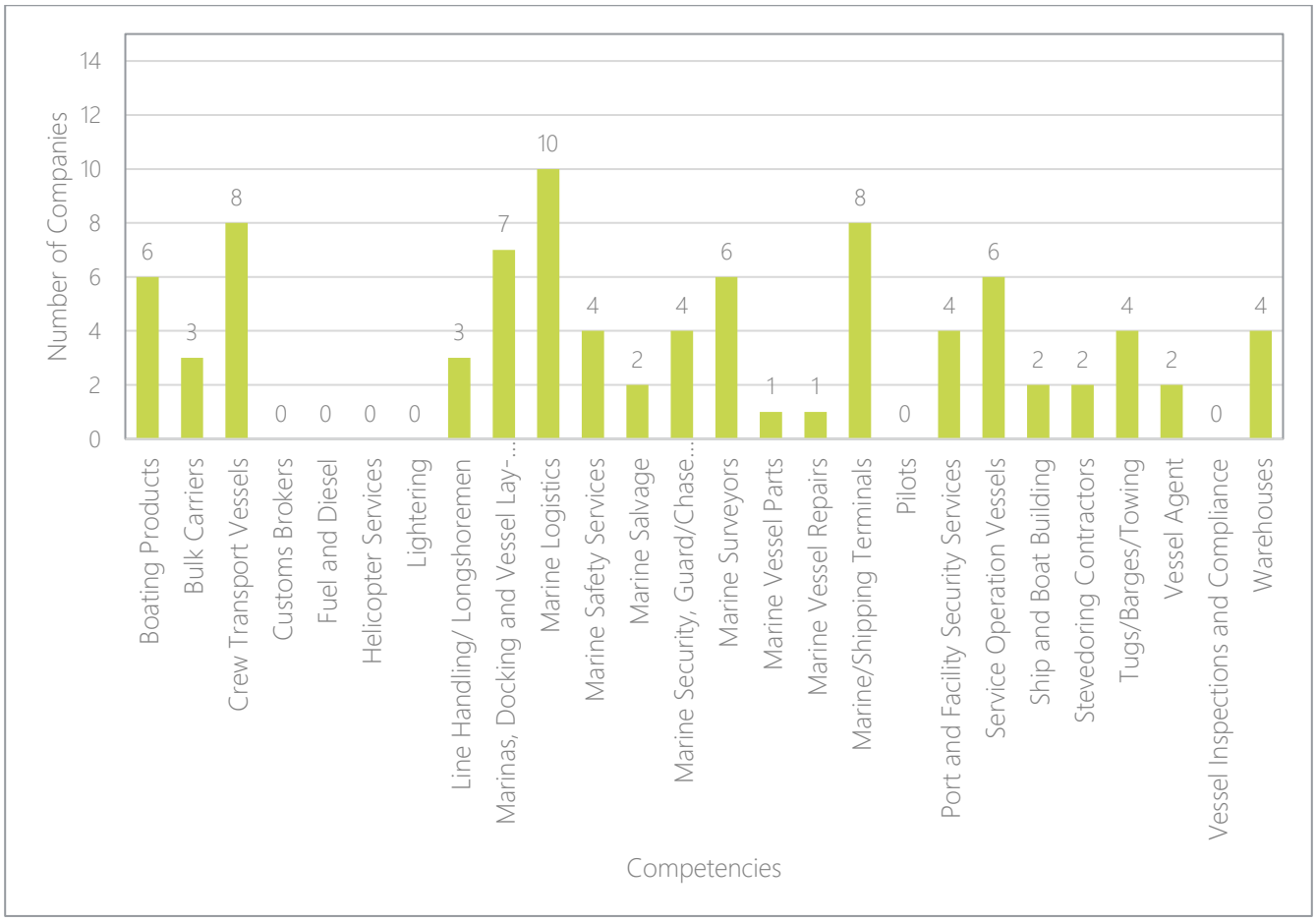


Figure 4-8 MassCEC Directory: Marine Facilities, Transport, Logistics and Safety Sector Breakdown

4.1.8 Offshore Wind Developer

The eighth industry sector that is present in the MassCEC Directory relates to Offshore Wind Developers. A total of 4 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-8.

Table 4-8 Number of Massachusetts Companies in MassCEC Directory with Capability Listed under Offshore Wind Developer

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Offshore Wind Developer	**Project Developer (Offtake, Permitting, Construction)**	**2**
	Project Operator	**1**
	Sponsor/Parent Company	**2**
	Transmission Developer	**1**
	Transmission Operator	**1**

While there are a limited number of companies within this sector, totalling only four in MA, this sector is what drives the need for other sectors within the directory. The projects set forth by the developers are what initiate the need for a robust supply chain in the state of MA. There does not necessarily need to be a significant number of developers listed within the directory, however, all the major developers should be present. In casting a broader net, a total of seven OSW developers are listed in the directory regardless of geographic location; it must also be stated that companies such as Ørsted, Shell and EDPR (Mayflower Wind) are not present in the directory at this time.

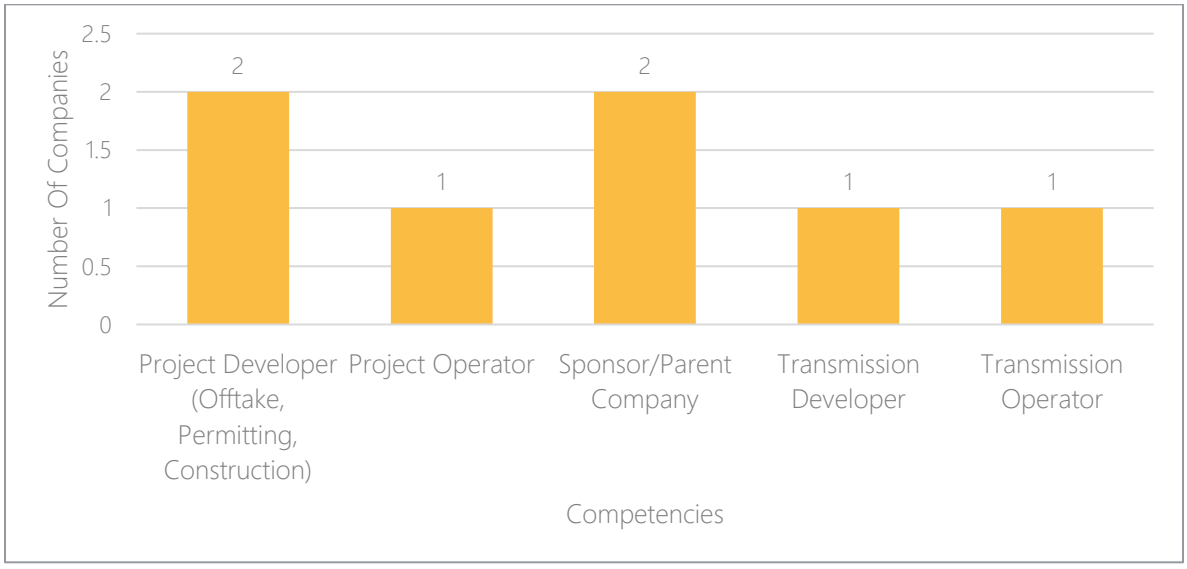


Figure 4-9 MassCEC Directory: Offshore Wind Developers Sector Breakdown

4.1.9 Offshore Wind Original Equipment Manufacturer (OEM)

The ninth industry sector that is present in the MassCEC Directory relates to Offshore Wind Original Equipment Manufacturers (OEMs). A total of 8 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-9.

Table 4-9 Number of Massachusetts Companies in MassCEC Directory with Capability in Offshore Wind Original Equipment Manufacturer (OEM)

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Offshore Wind Original Equipment Manufacturer (OEM)	**Blades**	**2**
	Electric Service Platforms (ESPs) and Substations	**3**
	Export Cables	**1**
	Foundations (Fixed Bottom)	**3**
	Foundations (Floating)	**4**
	Inter-Array Cables	**1**
	Nacelles	**2**
	Towers	**2**
	Transition Pieces	**2**

It is likely to be the case that the majority of the companies attributed to these competencies are not Tier 1 suppliers of equipment (blades, cables etc.) and more likely to be Tier 2/3 suppliers providing services and components to the Tier 1 Contractor. This can be misleading and potentially detrimental when attempting discern the strengths or competency gaps in the MA supply chain.

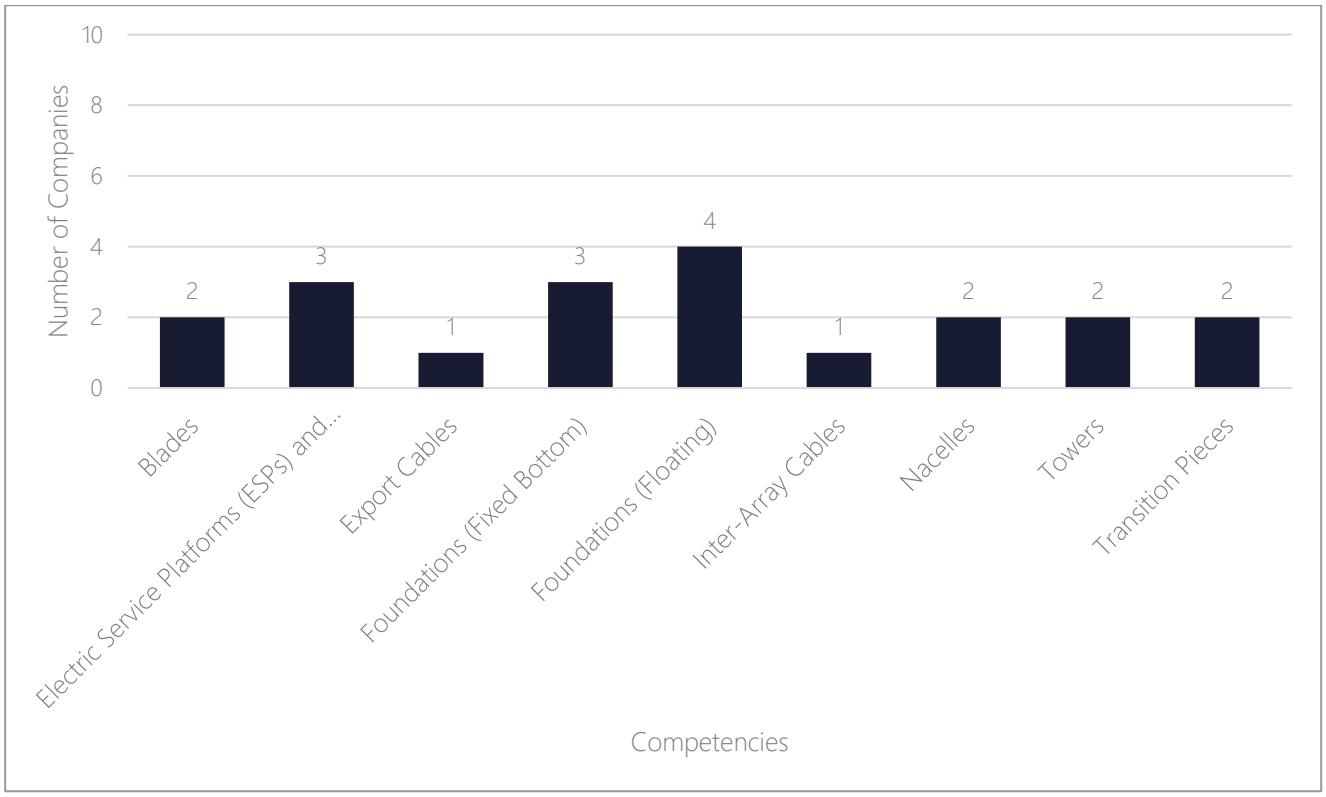


Figure 4-10 MassCEC Directory: Offshore Wind Original Equipment Manufacturer (OEM) Sector Breakdown

4.1.10 Professional & Consulting Services

The tenth industry sector that is present in the MassCEC Directory relates to Professional & Consulting Services. A total of 49 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-10

Table 4-10 Number of Massachusetts Companies in MassCEC Directory with Capability in Professional and Consulting Services

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Professional and Consulting Services	Accounts Payable	0
	Bookkeeping	0
	Business/Corporate Law	2
	Certification and Inspection Services	6
	Civil Litigation	2
	Communications and Marketing	8
	Contracting Services	8
	Employment and Labor Law	1
	Energy Markets and Procurement Consulting	18
	Energy Production Analysis and Optimization	13
	Financial Statement Preparation	1
	GIS Services	19
	Government and Public Relations	11
	Health and Safety Consulting	10
	Insurance	1
	Lending and Financing	4
	Mergers and Acquisitions Law	2
	Payroll Processing	0
	Software Development, Data Management and AI	5
	Tax Accounting Services	0
	Transmission and Interconnection Consulting	16

As with Section 4.1.3 MA continues to be a central hub for professional services. Supported by a nation leading education cluster the state will continue to grow and remain the gold standard resource for these services.

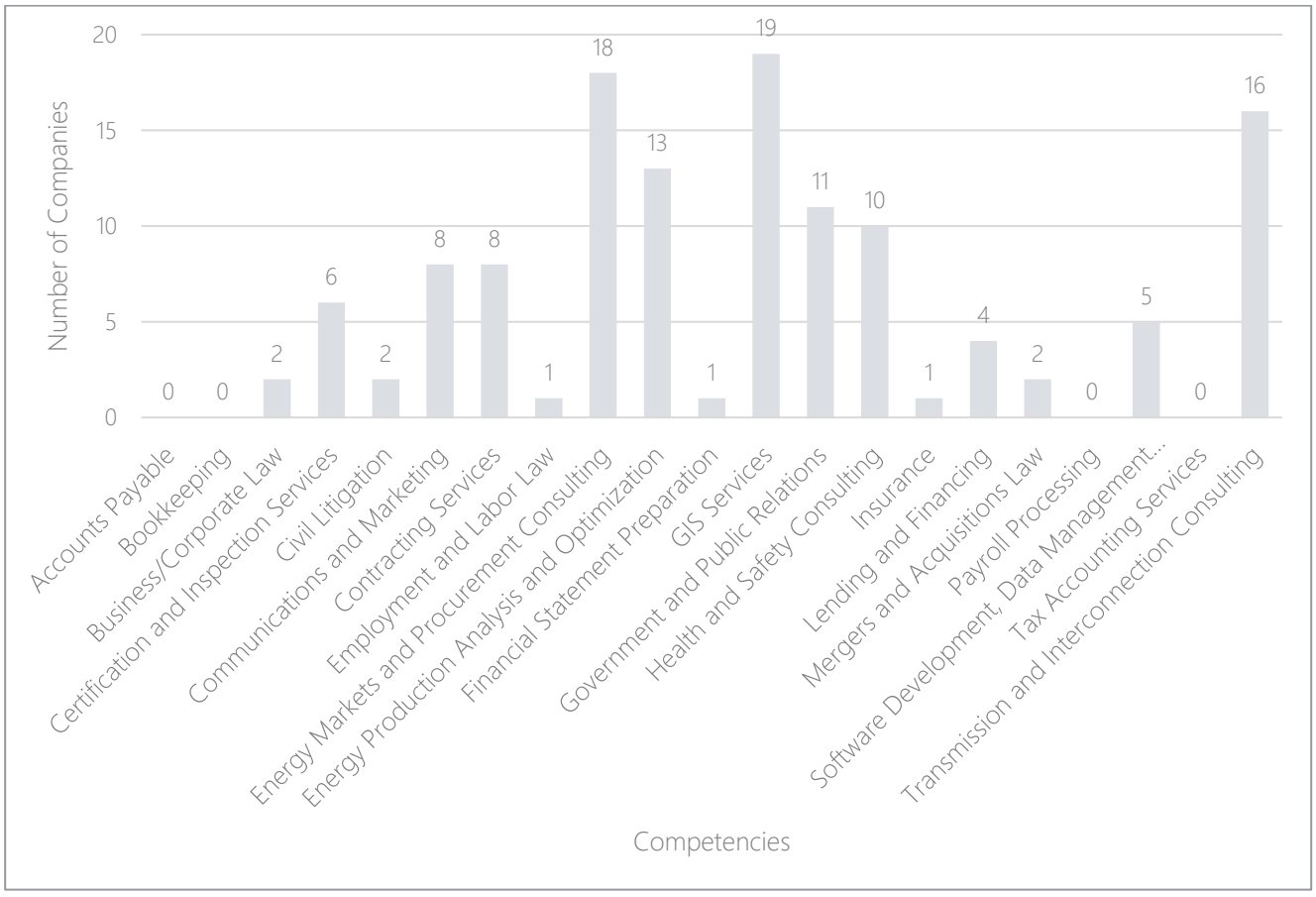


Figure 4-11 MassCEC Directory: Professional and Consulting Services Sector Breakdown

4.1.11 Trades, Labor & Workforce Organizations

The eleventh industry sector that is present in the MassCEC Directory relates to Trades, Labor & Workforce Organizations. A total of 9 companies from MA were listed in this sector, some of these companies covered more than one of the competencies described in the directory, with the total number of companies in each competency area given in Table 4-11

Table 4-11 Number of Massachusetts Companies in MassCEC Directory Listed as Trades, Labor and Workforce Organizations

INDUSTRY SECTOR	COMPETENCY	NUMBER OF COMPANIES LISTED
Trades, Labor and Workforce Organizations	**Labor Association**	**2**
	Non-Government Organization	**0**
	Recruitment and Staffing Services	**4**
	Trade or Industry Association	**3**
	Workforce Provider	**7**

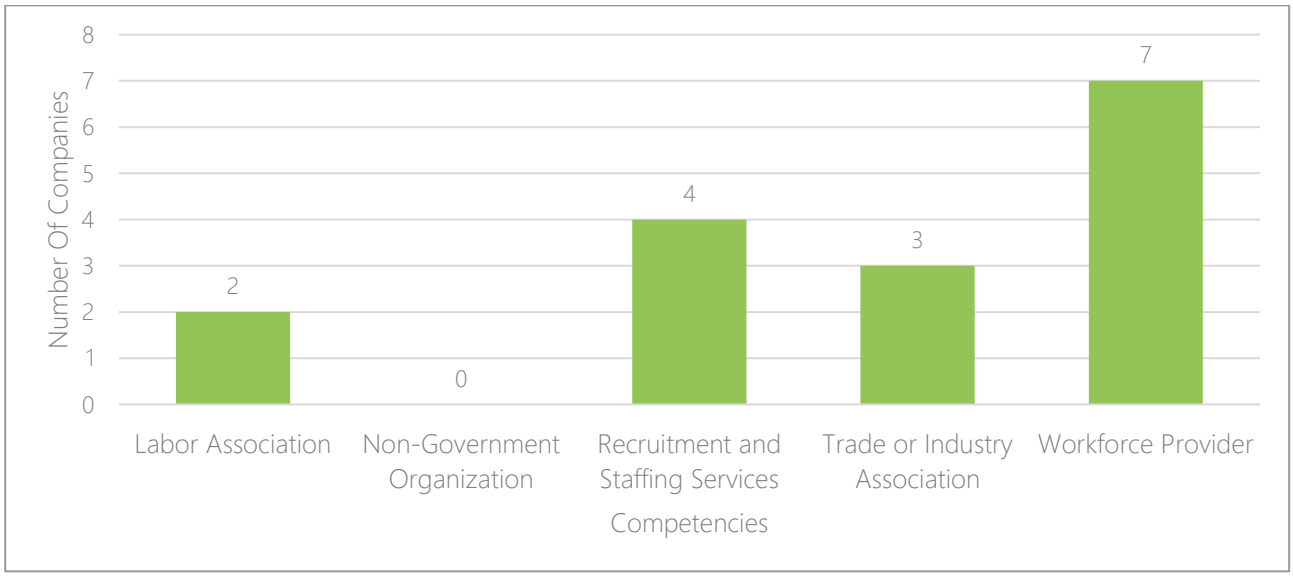


Figure 4-12 MassCEC Directory: Trades, Labor and Workforce Organizations Sector Breakdown

4.2 Xodus Group Taxonomy

The supply chain can also be classified in a way that is more closely aligned with typical contracting structures for an offshore wind project. The taxonomy for offshore wind supply chain classification aligned with this approach presented in Table 4-12 is proposed to be used for the purposes of this study. The third phase of the study will assess the strengths and gaps of the local supply chain capability within these elements.

Table 4-12 Offshore Wind Supply Chain Taxonomy

CATEGORY	SUPPLY ELEMENT
Project development	Development and consenting
	Surveys
	Engineering & design
	Project management
Wind turbine supply	Rotor
	Nacelle
	Electrical and auxiliary systems
	Tower
Balance of plant supply	Export cables
	Array cables
	Offshore substation
	Onshore substation
	Foundations
Installation and commissioning	Turbine installation
	Foundation installation
	Subsea cable installation
	Offshore substation installation
	Onshore construction
	Ports and logistics
Operations and maintenance	Operations
	Turbine inspection and maintenance
	BoP inspection and maintenance
Decommissioning	Decommissioning
Sector support	Educational Institution/ Training Provider
	Government Agencies
	Trades, Labor and Workforce Organizations

This approach comprises multiple supply elements that describe the broad requirements for products and services that enable the development, construction and operation of an offshore wind project. The elements within the categories of project development, wind turbine supply, balance of plant supply, and installation and commissioning generally represent Tier 1 and Tier 2 packages, or package areas, where supply is commonly fulfilled by a distinct provider or group of providers.

Due to the length of operational lifetime and range of services required, the operations phase of an offshore wind project typically comprises of hundreds of individual supply contracts. These services can be grouped into broad elements to enable analysis of supply chain capability. Similarly, the range of services required for wind farm decommissioning are varied but have been grouped for simplicity of analysis.

Sector support functions are not typically considered part of the offshore wind supply chain. However, this category and the constituent elements have been included for analysis as they are representative of the quality of the supply chain environment. Presence of good sector support organizations will be necessary for the growth and development of supply chain capability.

The bridging of this taxonomy with the competency categories of the MassCEC directory is given in the sections that follow.

4.2.1 Project Development

The project development category includes the services contracted prior to the developer reaching final investment decision (FID). This includes surveys and studies required to inform wind farm project and component design, as well as to obtain necessary planning consents. The MassCEC directory categories with some applicability to each of the elements within the project development category are given in Table 4-13.

Table 4-13 Description of Project Development Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Development and consenting	Construction, Installation and Operations & Maintenance	Site Development and Excavation
	Environmental, Engineering, Geological & Testing Services	Environmental Cleanup
		Environmental Permitting, Assessments, Analysis and Impact Statements/Reports
	Offshore Wind Developer	Project Developer (Offtake, Permitting, Construction)
		Sponsor/Parent Company

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
		Transmission Developer
	Professional and Consulting Services	Certification and Inspection Services
Surveys	Environmental, Engineering, Geological & Testing Services	Biological and Marine Life Surveys and Studies
		Meteorological Data and Testing
		Ocean Geophysical Survey
		Ocean Geotechnical Survey (Soil and Core Testing)
		Physical Oceanography (Currents, Waves, Tides)
		Protected Species Observing
		Remote Sensing Services
Engineering & design	Construction, Installation and Operations & Maintenance	Engineering Procurement, Construction and Installation (EPCI)
	Environmental, Engineering, Geological & Testing Services	Engineering: Civil
		Engineering: Electrical
		Engineering: Environmental
		Engineering: General
		Engineering: Structural
	Professional and Consulting Services	Energy Markets and Procurement Consulting
		Energy Production Analysis and Optimization
		GIS Services
		Health and Safety Consulting
Project management	Construction, Installation and Operations & Maintenance	Engineering Procurement, Construction and Installation (EPCI)
	Offshore Wind Developer	Project Developer (Offtake, Permitting, Construction)
		Transmission Developer

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
	Professional and Consulting Services	Accounts Payable
		Bookkeeping
		Business/Corporate Law
		Civil Litigation
		Communications and Marketing
		Contracting Services
		Employment and Labor Law
		Financial Statement Preparation
		Government and Public Relations
		Insurance
		Lending and Financing
		Mergers and Acquisitions Law
		Payroll Processing
		Software Development, Data Management and AI
		Tax Accounting Services
		Transmission and Interconnection Consulting

4.2.2 Wind Turbine Supply

The wind turbine supply category includes general components of the WTG supply contract. The assembly of the WTG is carried out by the WTG OEM with the rotor, nacelle, and electrical systems elements broad terms for a number of Tier 2 supply packages. The MassCEC directory categories applicable to each of the elements within the wind turbine supply category are given in Table 4-14.

Supply areas not covered in the MassCEC directory relevant to wind turbine supply includes bearings, generators (and components) and gearboxes (and components). While supply of specialist sub-elements such as pitch systems, yaw systems, power take-off systems, and control systems may be classified as mechanical and electrical components,

companies supplying in these areas may lack the specialist knowledge required to manufacture components for offshore wind turbines.

Table 4-14 Description of Wind Turbine Supply Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Rotor	Equipment, Supplies, Materials and Associated Services	Fasteners
	Manufacturing and Fabrication Services	Casting
		Coating
		Machining
		Mechanical Components
		Milling
		Painting
	Offshore Wind Original Equipment Manufacturer (OEM)	Blades
Nacelle	Equipment, Supplies, Materials and Associated Services	Fasteners
		Fire Protection Materials and Services
		SCADA and Central Monitoring Systems
	Manufacturing and Fabrication Services	Blasting
		Casting
		Coating
		Machining
		Mechanical Components
		Milling
		Painting
		Welding

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
	Offshore Wind Original Equipment Manufacturer (OEM)	Nacelles
Electrical and auxiliary systems	Construction, Installation and Operations & Maintenance	Electrical Services
	Manufacturing and Fabrication Services	Electrical Components/Electronics
Tower	Equipment, Supplies, Materials and Associated Services	Fabricated Steel Products, E. G. Decks, Platforms, Ladders and Rails
		Fasteners
		Fire Protection Materials and Services
		Steel Plate, Pipe or Bar
	Manufacturing and Fabrication Services	Blasting
		Coating
		Machining
		Milling
		Painting
		Rolling
		Welding
	Offshore Wind Original Equipment Manufacturer (OEM)	Towers

4.2.3 Balance of Plant Supply

The balance of plant supply category includes the remaining components of an offshore wind project beyond the supply of the WTG. These elements are typically Tier 1 packages. The MassCEC directory categories applicable to each of the elements within the balance of plant supply category are given in Table 4-15.

Supply areas not covered in the MassCEC directory relevant to balance of plant supply includes cable accessories, cable protection, scour protection, corrosion protection, and davit cranes. While supply of specialist sub-elements such as switchgear, transformers, converters and power compensators may be classified as electrical components, companies supplying in these areas may lack the specialist knowledge required to manufacture components for offshore wind substations.

Table 4-15 Description of Balance of Plant Supply Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Export cables	**Equipment, Supplies, Materials and Associated Services**	Cables (Electrical/Telecommunications)
	Offshore Wind Original Equipment Manufacturer (OEM)	Export Cables
Array cables	**Equipment, Supplies, Materials and Associated Services**	Cables (Electrical/Telecommunications)
	Offshore Wind Original Equipment Manufacturer (OEM)	Inter-Array Cables
Offshore substation	**Equipment, Supplies, Materials and Associated Services**	Cables (Electrical/Telecommunications)
		Electrical Components or Controls
		Fabricated Steel Products, E. G. Decks, Platforms, Ladders and Rails
		Fasteners
		Fire Protection Materials and Services
		Marine Horns and Lighting
		Steel Plate, Pipe or Bar
	Manufacturing and Fabrication Services	Coating
		Electrical Components/Electronics
		Machining

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
		Milling
		Painting
		Welding
	Offshore Wind Original Equipment Manufacturer (OEM)	Electric Service Platforms (ESPs) and Substations
Onshore substation	**Equipment, Supplies, Materials and Associated Services**	Aggregate/ Concrete
		Cables (Electrical/Telecommunications)
	Manufacturing and Fabrication Services	Electrical Components/Electronics
	Offshore Wind Original Equipment Manufacturer (OEM)	Electric Service Platforms (ESPs) and Substations
Foundations	**Construction, Installation and Operations & Maintenance**	Pre-Assembly
	Equipment, Supplies, Materials and Associated Services	Aggregate/ Concrete
		Fabricated Steel Products, E. G. Decks, Platforms, Ladders and Rails
		Fasteners
		Marine Horns and Lighting
		Steel Plate, Pipe or Bar
	Manufacturing and Fabrication Services	Blasting
		Casting
		Coating
		Machining
		Milling

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
		Painting
		Rolling
		Welding
	Offshore Wind Original Equipment Manufacturer (OEM)	Foundations (Fixed Bottom)
		Foundations (Floating)
		Transition Pieces

4.2.4 Installation & Commissioning

The installation and commissioning category includes the services contracted to construct an offshore wind project. These elements are can be Tier 1 or Tier 2 packages, with the exception of ports contracts which are typically Tier 2 or Tier 3. The MassCEC directory categories applicable to each of the elements within the installation and commissioning category are given in Table 4-16.

Table 4-16 Description of Installation and Commissioning Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Turbine installation	Construction, Installation and Operations & Maintenance	Electrical Services
		Wind Turbine Generator Installation
Foundation installation	Construction, Installation and Operations & Maintenance	Jacket Installation
		Monopile and Transition Piece Installation
		Pile Driving
	Equipment, Supplies, Materials and Associated Services	ROV, AUV, and Subsea Equipment
Subsea cable installation	Construction, Installation and Operations & Maintenance	Electrical and Cable Installation

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
	Equipment, Supplies, Materials and Associated Services	ROV, AUV, and Subsea Equipment
Offshore substation installation	Construction, Installation and Operations & Maintenance	Electrical and Cable Installation
		Electrical Services
		Jacket Installation
		Pile Driving
Onshore construction	Construction, Installation and Operations & Maintenance	Construction and Logistics Management
		Crane Lift Operations
		Land-Based Construction
		Site Development and Excavation
Ports and logistics	Construction, Installation and Operations & Maintenance	Dredging
	Equipment, Supplies, Materials and Associated Services	Forklifts and Trucks
		Fuel and Diesel
		Heavy Lift Cranes, Crawler Cranes and Modular Transport
		Lifting Appliances, Rope, Rigging and Slings
		Warehouses and Storage
		Waste and Facilities Management
	Marine Facilities, Transport, Logistics and Safety	Boating Products
		Bulk Carriers
		Crew Transport Vessels
		Customs Brokers
		Fuel and Diesel
		Lightering

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
		Line Handling/ Longshoremen
		Marinas, Docking and Vessel Lay-Over
		Marine Logistics
		Marine Safety Services
		Marine Security, Guard/Chase Vessels and Services
		Marine Surveyors
		Marine Vessel Parts
		Marine Vessel Repairs
		Marine/Shipping Terminals
		Pilots
		Port and Facility Security Services
		Ship and Boat Building
		Stevedoring Contractors
		Tugs/Barges/Towing
		Vessel Agent
		Vessel Inspections and Compliance
		Warehouses

4.2.5 Operations & Maintenance

The operation and maintenance category includes the services contracted to support the continuing operation of an offshore wind project. Turbine inspection and maintenance is typically carried out by the WTG OEM for at least the first five years of operation with services sub-contracted by them. Other operations, inspections and maintenance services are typically contracted by the project owner. The MassCEC directory categories applicable to each of the elements within the operation and maintenance category are given in Table 4-17.

Communications equipment is a supply area that does not appear to be covered in the MassCEC directory. While supply of specialist sub-elements services such as blade and nacelle inspection and repair may be classified as Certification and Inspection Services or Material Testing and Inspection, companies supplying in these areas may lack the specialist knowledge required to carry out turbine inspection and servicing.

Table 4-17 Description of Operations and Maintenance Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Operations	Environmental, Engineering, Geological & Testing Services	Environmental Cleanup
	Equipment, Supplies, Materials and Associated Services	Engine/Diesel Parts
		Engine/Diesel Repairs (Non-Marine Vessels)
		SCADA and Central Monitoring Systems
		Warehouses and Storage
		Waste and Facilities Management
	Marine Facilities, Transport, Logistics and Safety	Boating Products
		Bulk Carriers
		Customs Brokers
		Fuel and Diesel
		Helicopter Services
		Line Handling/ Longshoremen
		Marinas, Docking and Vessel Lay-Over
		Marine Logistics
		Marine Safety Services
		Marine Security, Guard/Chase Vessels and Services

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
		Marine Surveyors
		Marine Vessel Parts
		Marine Vessel Repairs
		Marine/Shipping Terminals
		Pilots
		Port and Facility Security Services
		Service Operation Vessels
		Ship and Boat Building
		Stevedoring Contractors
		Tugs/Barges/Towing
		Vessel Agent
		Vessel Inspections and Compliance
		Warehouses
	Offshore Wind Developer	Project Operator
		Transmission Operator
	Educational Institution/ Training Provider	Health, Safety and Environmental Training
		Workforce and Skilled Trades Training
	Trades, Labor and Workforce Organizations	Recruitment and Staffing Services
		Workforce Provider
Turbine inspection and maintenance	Construction, Installation and Operations & Maintenance	Electrical Services
		Mechanical Services
	Environmental, Engineering, Geological & Testing Services	Material Testing and Inspection

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
	Equipment, Supplies, Materials and Associated Services	Drones
	Professional and Consulting Services	Certification and Inspection Services
BoP inspection and maintenance	Construction, Installation and Operations & Maintenance	Diving
		Electrical Services
		Mechanical Services
	Environmental, Engineering, Geological & Testing Services	Material Testing and Inspection
	Equipment, Supplies, Materials and Associated Services	Drones
		Generators, Compressors, Portable Welders, Pumps and Motors
		Hand Tools, Power Tools and Painting Supplies
		Personal Protection Equipment (PPE)
		ROV, AUV, and Subsea Equipment
		Welding Supplies
	Professional and Consulting Services	Certification and Inspection Services

4.2.6 Decommissioning

The decommissioning category includes the services contracted to remove, make safe or dispose of wind farm components at the end of project lifetime. The MassCEC directory categories applicable to the element within the decommissioning category is given in Table 4-18.

Table 4-18 Description of Decommissioning Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Decommissioning	Environmental, Engineering, Geological & Testing Services	Environmental Cleanup
	Marine Facilities, Transport, Logistics and Safety	Marine Salvage

4.2.7 Sector Support

The sector support category includes services that will benefit the development of the supply chain but that may not be contracted directly as the result of an offshore wind project. The MassCEC directory categories applicable to each of the elements within the sector support category are given in Table 4-19.

Academic or non-academic research and development organizations is a sector support area that does not appear to be covered in the MassCEC directory.

Table 4-19 Description of Sector Support Elements

ELEMENT	APPLICABLE MASSCEC DIRECTORY CATEGORIES	
	INDUSTRY SECTOR	COMPETENCY
Educational Institution/ Training Provider	Educational Institution/ Training Provider	College Degree Programs
		Health, Safety and Environmental Training
		K-12 Curriculum and Instruction
		Skilled Trades (Mechanical, Electrical, Welding)
		Vocational High School
		Workforce and Skilled Trades Training
Government Agencies	Government Agencies	Economic Incentive Programs
		Energy Procurement and Regulation
		Environmental Review and Permitting
		Planning and Policy
		Programmatic Support for Offshore Wind
		Workforce Development
Trades, Labor and Workforce Organizations	Trades, Labor and Workforce Organizations	Labor Association
		Non-Government Organization
		Recruitment and Staffing Services
		Trade or Industry Association
		Workforce Provider

5 TASK A - CONTRACTING STRATEGIES

Ambiguous and complex procurement practices can be difficult to navigate at the best of times. This is then compounded when discussing nascent supply chain environments. A lack of awareness of opportunities and how these are contracted create a barrier to securing contracts.

Standardized and simpler procurement processes are considered key to solving some of these issues, however, in practice this can be difficult due the variety of contracting strategy combinations available to the Developers and Tier1 sub-contracting. Therefore, providing support to local industry to help navigate the current context is critical.

The approach to contracting strategies in the offshore wind industry in generally influenced by multiple variables:

- Size and complexity of the project to be executed;
- Internal strength, experience and capabilities of the offshore wind farm developer;
- Influence of project financing availability and;
- Maturity of the local supply chain.

In the development of an offshore wind farm the developer usually prefers one of the below strategies (discussed in further detail in the following sections):

- A multi-contract strategy;
- An engineering, procurement, construction, and installation (EPCI) strategy;
- A hybrid/multi-contract/EPCI strategy.

Historically in the US, companies developing and operating solar, wind, and other renewable energy projects often work onshore. The contracting structures and forms used in such projects are very similar to other onshore infrastructure projects and often take the form of turn-key 'one-stop' contracts (an example of which is detailed in Section 5.2). The type of contracts applied to onshore projects do not consider the specific risks and challenges of operating in an offshore marine environment and we have seen this to be a key obstacle in project finance. The increased risk of cost and schedule overrun from multiple project interfaces currently presents too large of an unknown to banks/lenders (in the US) when the added challenges of an immature local supply chain and the Jones Act are also posing key project risks.

5.1 Multi-Contract Strategy

For a multi-contract strategy, the owner operator/developer will typically award separate contracts for the key elements of the wind farm (for example turbine supply, foundation supply, turbine installation, cable installation and foundation installation) see Figure 5-1. It has been seen that typically 9-10 main contracts can be awarded covering the main components of an offshore wind farm.

The multi-contract approach offers the greatest control over project development and the best opportunities for cost reduction, but it requires an owner operator/developer with very strong in-house engineering expertise, commercial skills, and experienced personnel. A multi-contracting approach requires the developer to play a greater role in managing interface risk and coordination between the various contractors. It is therefore often more suitable and preferred by large utilities or developers with extensive experience in executing offshore wind project (such as Equinor, Ørsted and Avangrid). These large utilities/developers may be less likely to be reliant on project finance and as such can take this risk internally rather than pay a (perceived) premium for an EPCI solution.

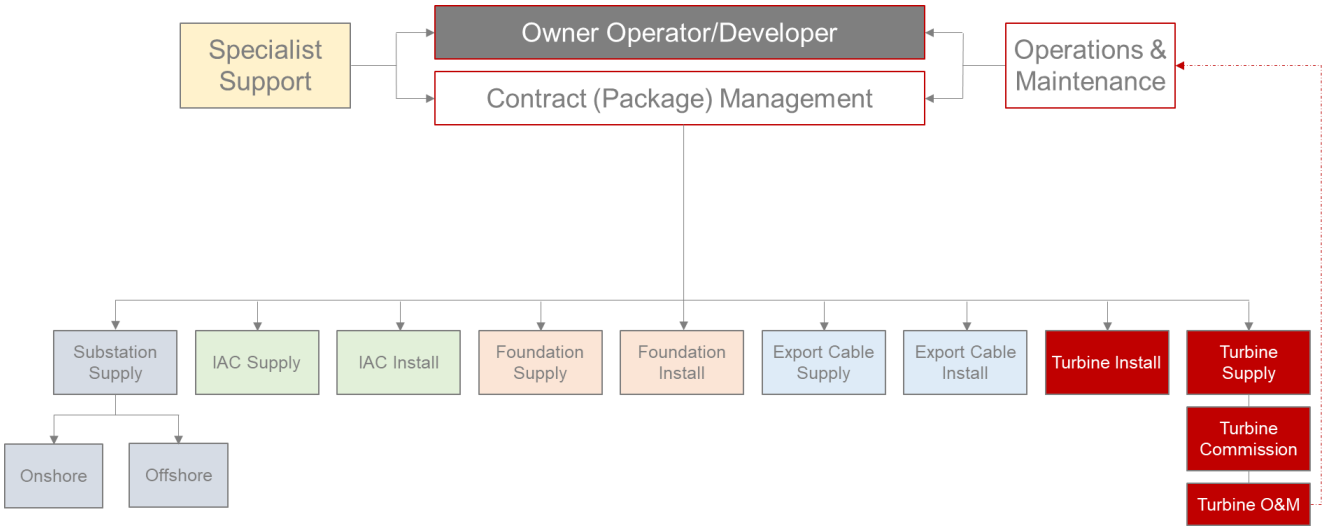


Figure 5-1 Typical Multi Contract Solution

5.2 EPCI Strategy

An EPCI strategy has generally fewer (2-4) contracts covering larger scopes of work, see Figure 5-2, for example:

- Turbines: the supply/installation/operation of turbines under one contract;
- Balance of Plant: Supply/installation of foundations and cables under another;
- Transmission and Distribution: Supply/installation of substations (onshore and offshore) and export cables under another.

This strategy is viewed as a turnkey solution of the entire contractual scope, which would typically mean that the contractor takes on the cost, schedule and interface risk including coordination with sub-contractors.

This generally mean that the EPCI contractor will 'price-in' these additional risks to allow for contingency due to any project issues although most contractors are now willing to accept these risks as they have now learned a lot more about executing large scale offshore wind projects. From the developer's perspective the risk profile under an EPCI contract may however be preferable, particularly through the lens of independent developers, less experienced utilities and/or their investors/financiers.

A complicating factor in respect of the above is that whilst the offshore oil and gas industry follow a well-established division of work-scopes banks/lenders, developers and EPCI contractors involved in offshore wind EPCI projects may have different expectations as to what constitutes a reasonable division of risk.

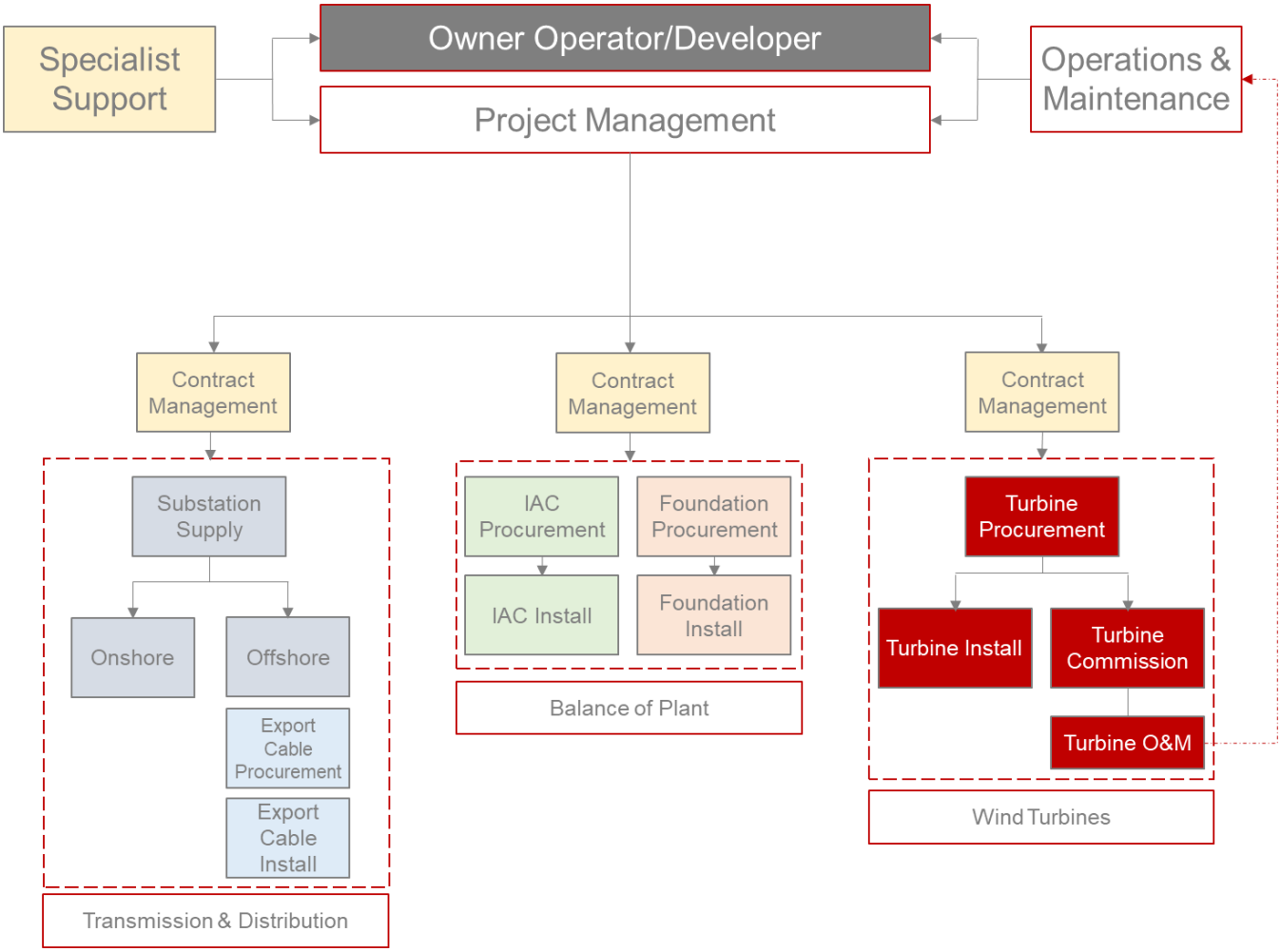


Figure 5-2 Typical EPCI Contract Solution

Some project examples that show the shift in the UK and Europe toward this model include Seagreen, currently Scotland largest planned wind farm, have taken a 4 contract EPCI approach as detailed below.

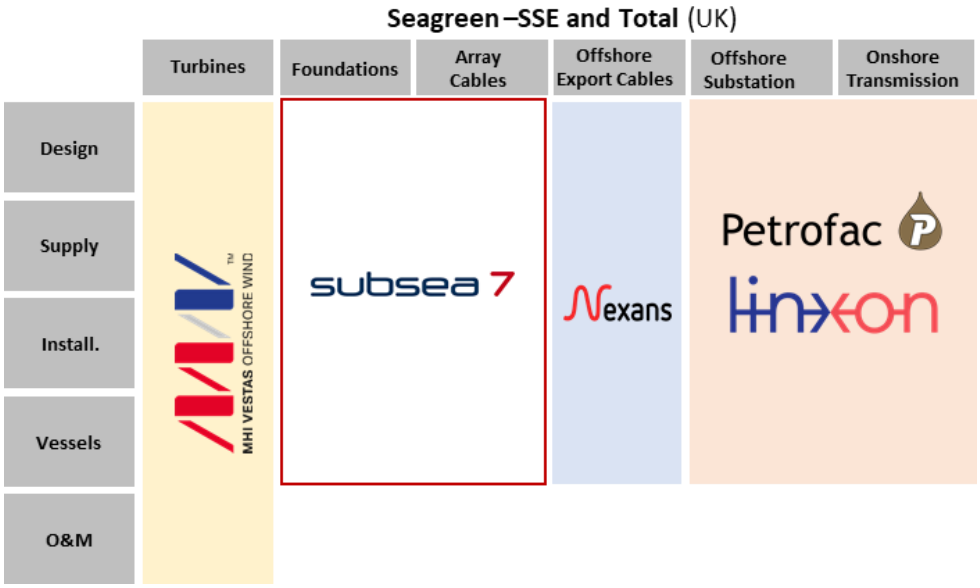


Figure 5-3 *Seagreen Project Contract Solution (As of 11/13/20)*

Gemini Wind park in the Netherlands has gone one step further and has only 2 contracts one with Siemens for the turbines and a main contract with Van Oord for the foundations, substation (onshore and offshore), the cables (export and IAC, and turbine installation. It is worth noting that Siemens and Van Oord have taken project equity which is recognized as way to enable more EPCI contracts.

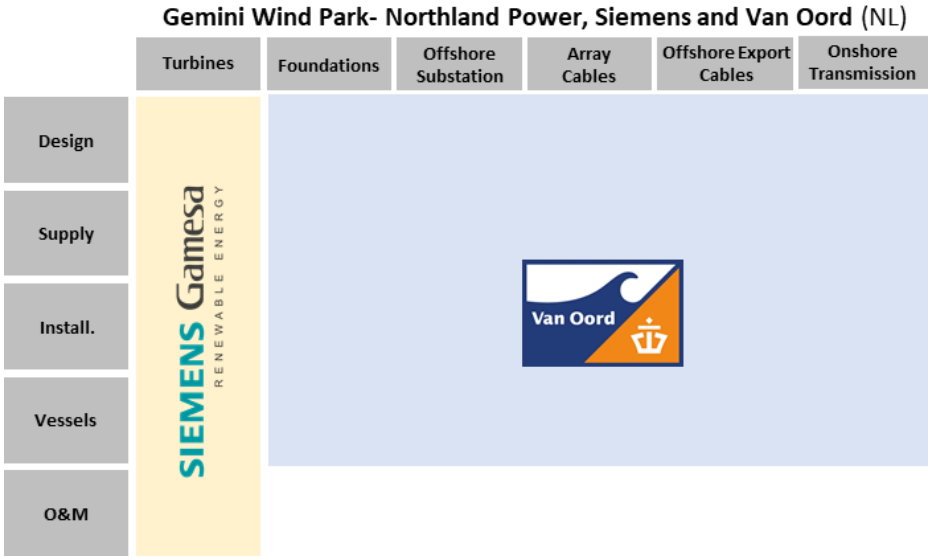


Figure 5-4 Gemini Project Contract Solution (As of 11/13/20)

5.3 Hybrid Strategy

In some cases, a hybrid approach between multi-contracting and EPCI has been adopted. This involves combining certain major packages depending and reduce construction risk while maintaining good project oversight.

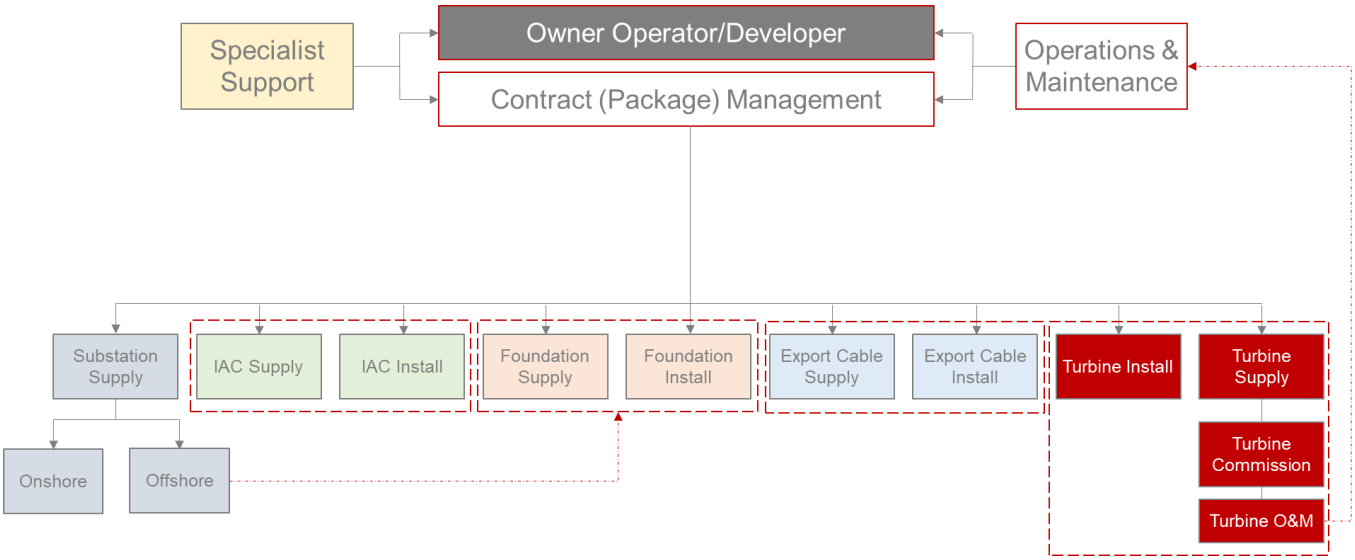


Figure 5-5 Hybrid Project Contract Solution

The trade-off between project risk and oversight across the varying contracting strategies is detailed below.

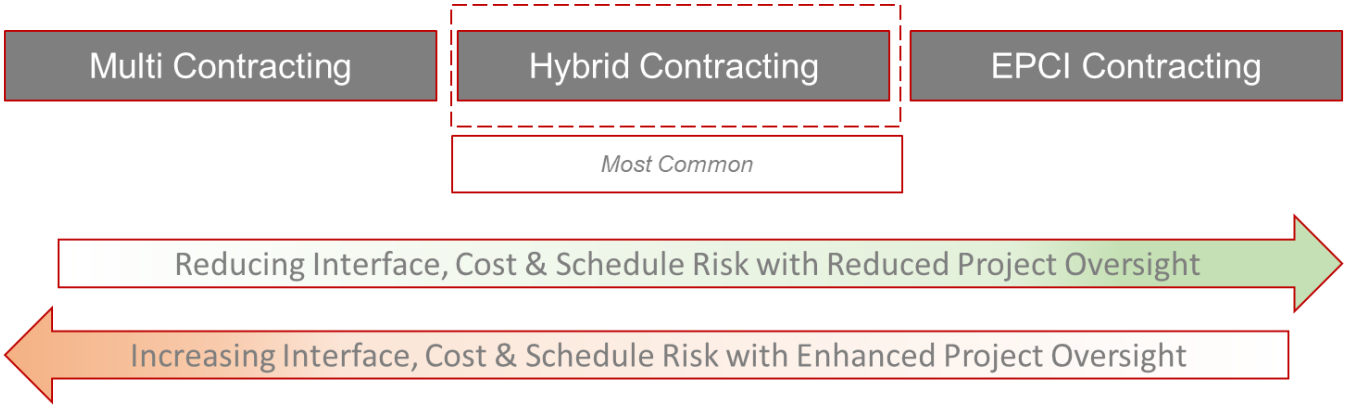


Figure 5-6 Project Risk and Project Oversight Relationship

Vineyard wind is a good example of where the developer has sourced various packages, as illustrated in the figure below. The below has been sourced from publicly available information and may be subject to change.

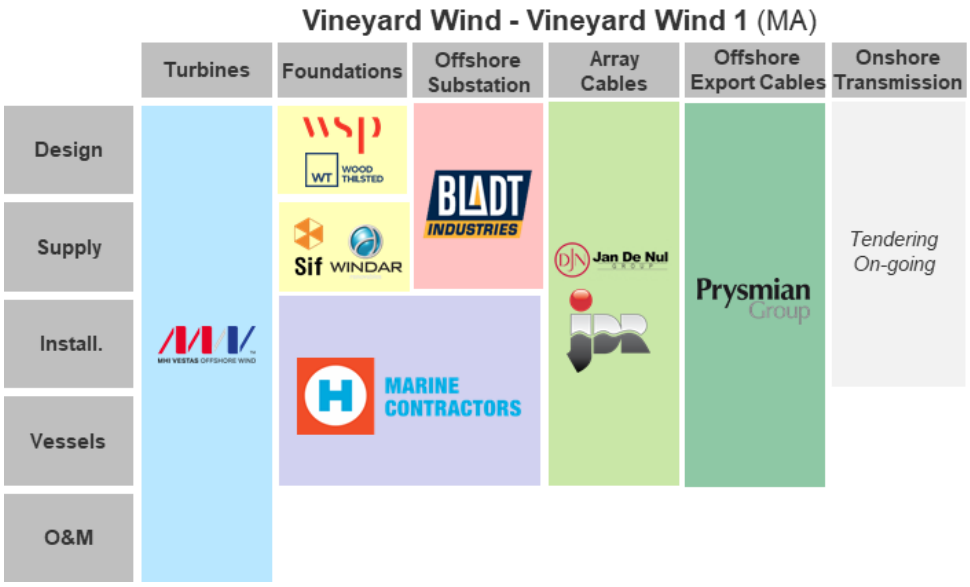


Figure 5-7 Vineyard Wind Project Contract Situation (As of 11/13/20)

6 TASK A - PRELIMINARY CONCLUSIONS

The development of the supply chain can be summarized by the graphic below.

Timing plays a large role in both Developer and Tier 1s attention to the supply chain. MA position is indicated by the green oval.

The real growth in the supply chain will mirror the OSW project approval cycle. As the industry moves from early projects to scale, the role of the supply chain will be increasingly important. Early projects will be supported by existing (mostly European) supply chains as the US supply chain has yet to be tested and developed. This is not a sustainable model for the industry as it matures as there are pressure for lower cost and higher development efficiency.

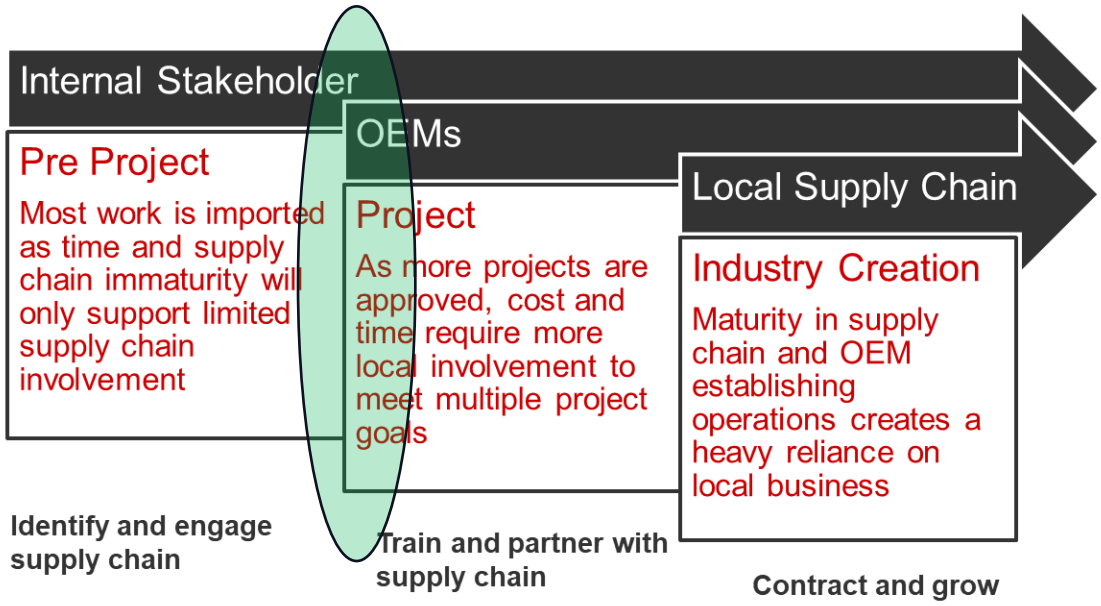


Figure 6-1 Development Stages of Local Supply Chain

6.1.1 Project Timing and Supply Chain Growth

The early projects will have limited involvement by the local supply chain due to their shorter time frames, lack of supply chain maturity and firm commitments of future projects. This will change quickly as more projects are approved and a stable pipeline develops. Developers and Tier 1s alike are anxious to grow and support the local supply chain and are actively engaging potential partners. Tier 1s and Developers are using this time to identify, engage and coach local

supply chain companies to prepare them for the work ahead as more projects come online. This process will mirror project timelines.

Currently, Tier 1s will use their existing supply chain in most cases to deliver early projects, this cannot be sustained as multiple projects come online. Tier 1s need a local supply chain to support pipeline growth and are actively evaluating supply chain capabilities. They are willing partners to help drive supply chain maturity.

6.1.2 6.1.2 Engagement Opportunities

Looking at the development of the supply chain in sync with project adoption points to an engagement strategy for the Mass CEC that can set measurable goals and a streamlined implementation process. The more complex the supply chain offering, the longer the process to adoption by an Tier 1. The Tier 1s are open to sharing as much information as needed to ensure the local supplier clearly understands the technical, financial and timing requirements of the partnership. Early interactions will allow the time for the local supply chain to be fully compliant and ready to meet the demands of growing projects.

The Tier 1s and Developers want to engage the local supply chain but are having a difficult time in knowing where to start. Current databases of companies do not provide the level of detail necessary for substantive discussions to take place, which are essential in supply chain growth. Face-to-face or virtual interaction is the encouraged, but the Developers and Tier 1s would like a means to cull databases to more accurately sort to their specific requirements. A more robust prequalification procedure would be very helpful.

6.1.3 Supply Chain Concentration

The Developers are currently not using EPC or EPCI contracting but are replicating European Package structures. The local supply chain is not at a point to support these types of contracts. Developers are also creating custom packages that may span related work goals in order to take advantage of local supply chain offerings. They want to move in the direction of EPC and EPCI contracts and will do so as soon as they are supported. Developers are more focused on the Tier 1s and the result is Developers' supply chain involvement is less than the Tier 1s. The Developers are pushing most of the local content interaction on the Tier 1s. There are limited cases where Developers will select Tier 2/3 suppliers, and these revolve around the most critical components. PLA pricing if it exists is given to the Tier 1s for FTE and budgeting purposes, but the Tier 1s are not involved in PLA negotiations to date.

6.1.4 Manufacturing and Supply Chain Development

If MA could attract a major OEM or Tier 1 manufacturing facility, this would rapidly grow the supply chain as a manufacturing plant will serve as a hub of supply chain development. Incentives could be used to attract the manufacturer as the investment is large and by showing a willingness to coinvest in success MA would demonstrate further commitment to the OSW industry. The goal would be to form a cluster and both Tier 1s and developers would fully support such an effort.

6.1.5 Workforce

Workforce development needs to be evaluated in terms of skill set, availability and timing. MA is especially strong in engineering and technical employees. The concentration of universities and technical businesses will be able to support industry growth and scale. While it appears the trade workforce is adequate, there were questions regarding its ability to scale. There was not universal knowledge of the workforce training programs available in the state and the recruiting methods to grow the workforce. The timing of training needs to coincide with development of projects. MA needs to align its training (both OSW specific, such as GWO and skills) to ensure workers are available when they are needed. As this may be a steep ramp, planning is a critical success factor. The Tier 1s and Developers are eager to support and provide input into the type of training and their need for workers.

6.1.6 Communicating the Supply Chain

Communication of supply chain capabilities, requirements and opportunities is crucial to success has been identified as one of the biggest areas of future focus and attention.

Proper communication between stakeholders and external suppliers through more creative ideas (such as the outcomes of Service Area 2) will be key to improving the process and foresight of opportunities. If people from different points of the process are able give ideas for these improvements based on first-hand experience, it stands to reason that this will make for a much better managed process.

OEMs and Tier 1 Contractors expressed a difficulty in sorting through lists and databases as they do not include the searchable items they need to identify potential partners. This is an area MassCEC could support the development of to assist in communication of the opportunities.

6.1.7 Ports and Harbors Assets

In 2010 it was identified that there were no port facilities that were in a position to support the development of an offshore wind farm. Since that time significant investment has been made, particularly in the New Bedford Marine Commerce Terminal to position it as a key asset to the state and a location to build a supply chain around.

During the course of the interviews it was clear that all contributors felt that Port of New Bedford was a huge asset to the state but expressed concern that this asset alone was not sufficient to support the growth of an entire industry. A deeper dive is required into the physical capabilities and port offering as there seemed to be a lack of clarity on what the resources are. This is reflected in the lack of companies listed in certain subareas of the MassCEC supply chain database.

Further clarity is required around the potential for the use of Brayton Point as this asset was raised as a potential asset for staging projects. Although it was clear that there is a disconnect in terms of available state funding to support the re-development of privately owned assets in order for them to meet the requirements of the developers or Tier 1s.

6.1.8 Regional Approach

The Tier 1s and developers look at the supply chain regionally and agreed that a multistate approach to the supply chain would help develop the local (state) supply chain. Through the course of this work an assessment of neighboring states and identifying their strengths is a big step in the right direction in working towards a multi-state regional supply chain cluster, offering the industry a wide network and the best of what each state has to offer. It will also ensure MA do not attempt to bridge any limitation in capability that may be insurmountable or offer little return on investment.

6.1.9 Local Content Requirements

Local content requirements are recognized as having a key part to play in the success of the MA supply chain and are becoming a key factor in contracting of Tier 1 major packages. Although to date Tier 1s supply chain decisions have been less focused on local content and more on project delivery with the thinking that Overly restrictive local content rules could slow the deployment of offshore wind and therefore progress. Tier 1s however also understand that local content 'accounting' will play crucial success factor for the Developer's reputation in the state and US industry as a whole and are generally receptive to local content requirements specifically called out by developers. For the Tier 1s, it will be a balance of retaining freedom of optimizing their solutions/delivery model to give them a competitive edge with an understanding that as global demand for offshore wind increases the requirement for local manufacturing/supply will be required.

6.1.10 Massachusetts Leading the Way

MA was viewed as doing a very good job, if not the best job, in comparison to neighboring states but with the recognition that other states are accelerating their involvement in the industry. In particular, NY/NJ, and now VA, are viewed as large scale manufacturing hubs for the industry.

MA has committed to multiple competitive solicitation round for offshore wind resources and is clearly committed to OSW success. The continued solicitation of OSW resources will serve as confidence that MA remains the leader in the market and the build-up and build-out of the supply chain will follow as these projects come to fruition.

7 TASK B - MA SUPPLY CHAIN SURVEY

7.1 Overall Supply Chain

There are currently 492 firms operating in Massachusetts that are current participating in or are interested in participating the offshore wind industry. The map below displays the distribution of the firm locations by county. Fourteen of the firms currently have no Massachusetts location but employ workers in state.

Collectively, the firms employ an estimated 31,800 workers across Massachusetts. This total includes survey responses, as well as non-respondent employment estimates based on available data. To note, respondents were asked to count only Massachusetts-based employees working in their primary industry sector.

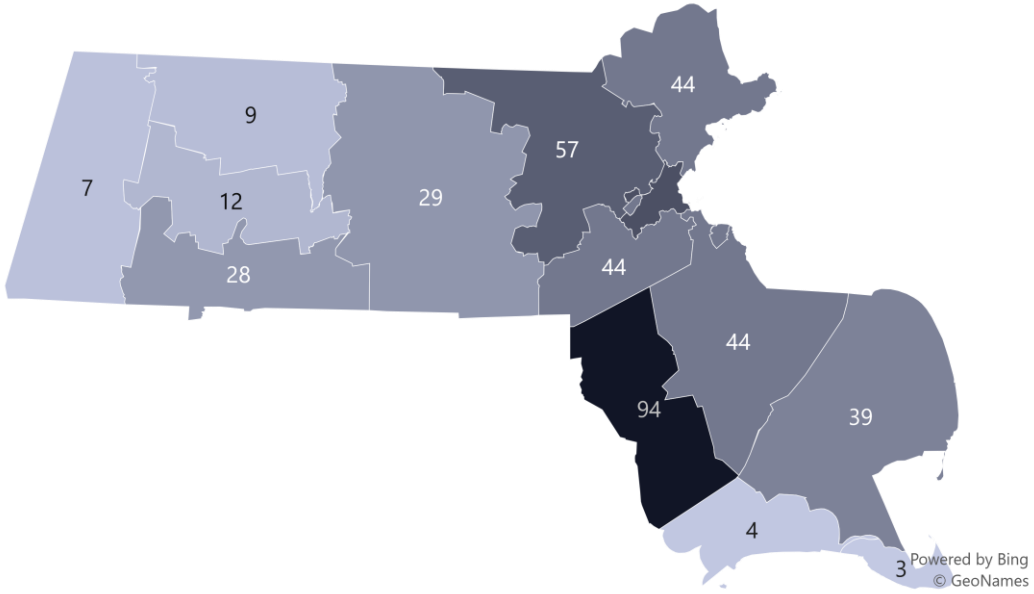


Figure 7.1 - Massachusetts OSW Supply Chain Firms by County, February 2021

Over half (58 percent) of surveyed firms report being current involved in work related to the wind energy industry. Among those firms, most (52 percent) are involved in the Project Development phase, followed by 42 percent involvement in Sector Support.

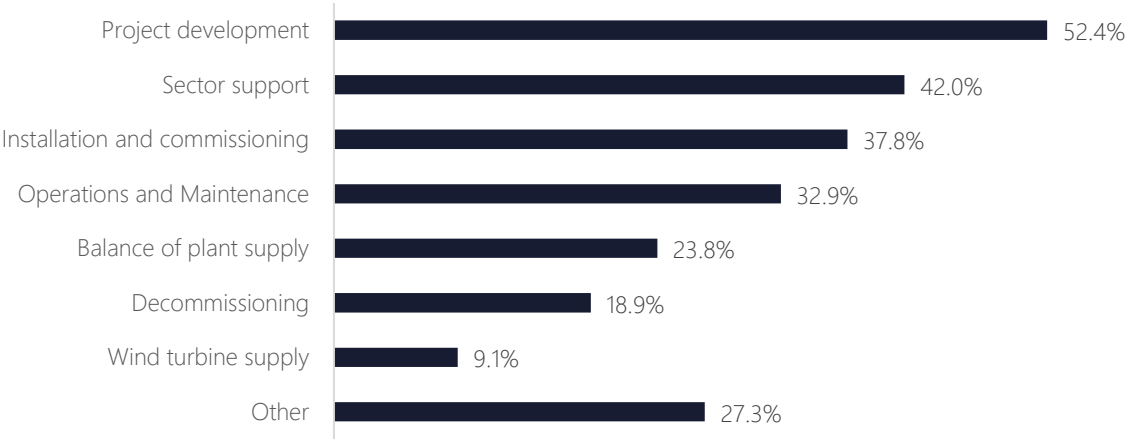


Figure 7.2 - Share of current wind energy firms operating in each phase

7.2 Construction and Operations

7.2.1 Construction, Installation, and Operations/Maintenance Services

Fifty-nine (59) firms primarily operate in Construction, Installation, and Operations/Maintenance Services; employing an estimated 3,900 workers.

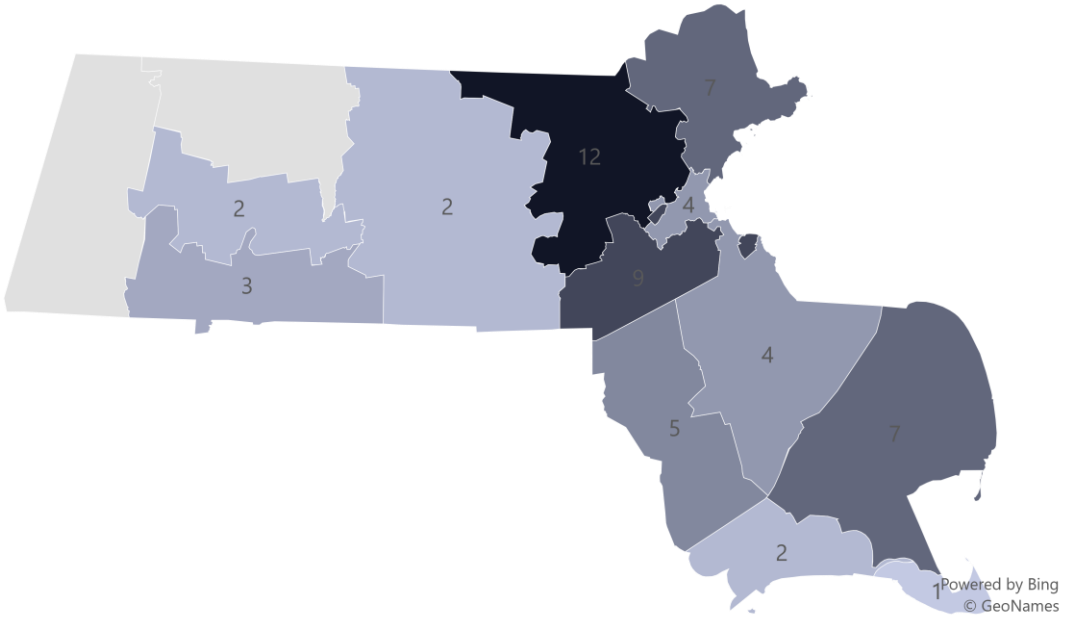


Figure 7.3 - Primary Construction/Installation/O&M firms by county

Among the 28 firms that completed the survey, a large share (43 percent) work in the land-based construction subsector; this is trailed by the Construction & Logistics Management and Site Development & Excavation subsectors (35 and 32 percent of firms, respectively).

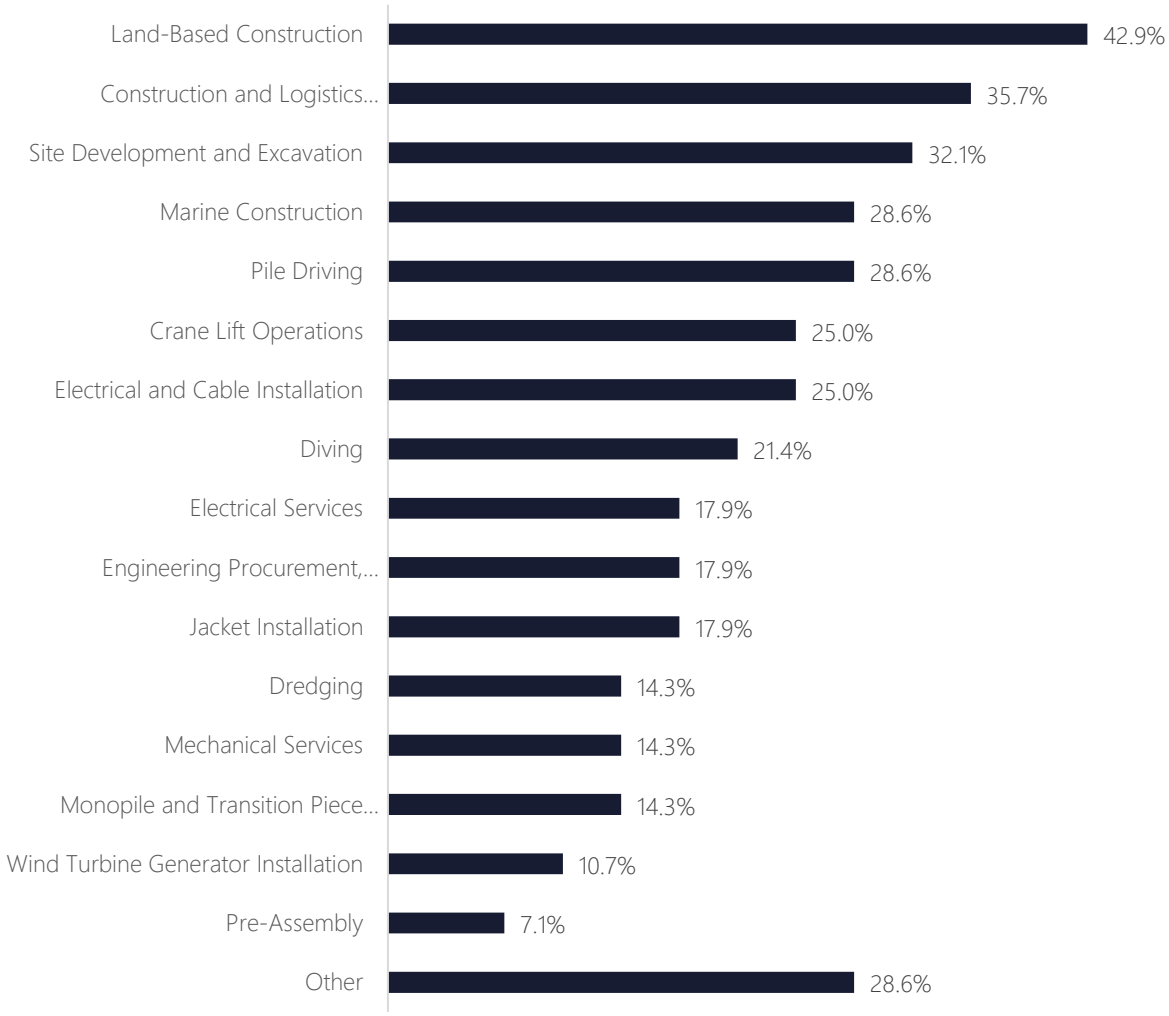


Figure 7.4 - Share of Construction/Installation/O&M firms operating within each subsector

The surveyed firms are largely interested participating in the offshore wind industry (58 percent somewhat or strongly agree) and have services that can be used by the OSW industry (65 percent). Roughly one-third (30 percent) agree, however, to needing significant capital investments in order to serve the industry, and half (50 percent) believe that their staff would need additional training.

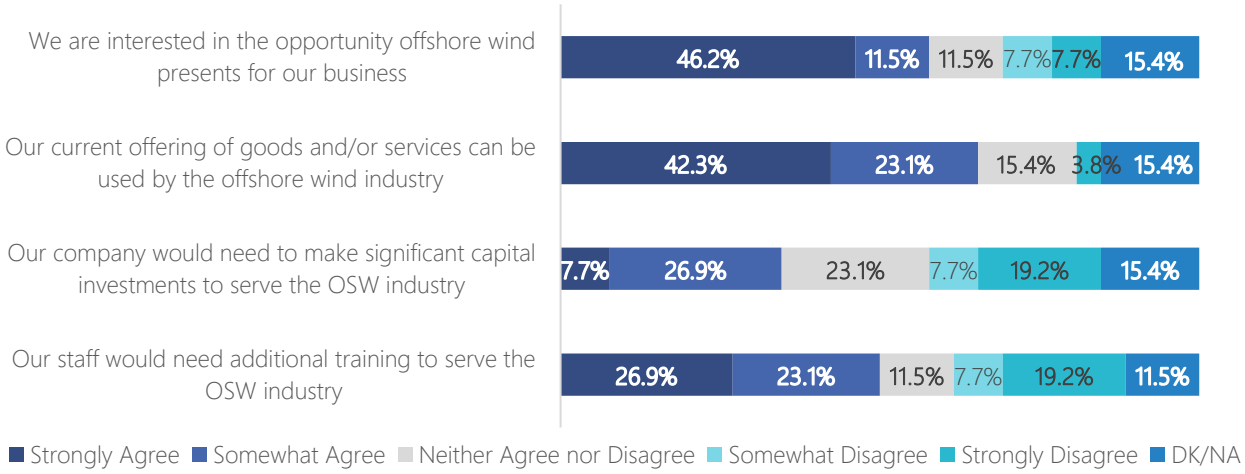


Figure 7.5 - Interest/capabilities of Construction/Installation/O&M firms in offshore wind industry

Construction, Installation, and Operations/Maintenance firms are slightly more optimistic than not about the state of the local supply chain. Only 19 percent find to there to be insufficient local qualified talent, 11 percent find insufficient market demand, and 8 percent find insufficient available equipment. Notably, however, 19 percent of the sector's respondents could not report on each factor.

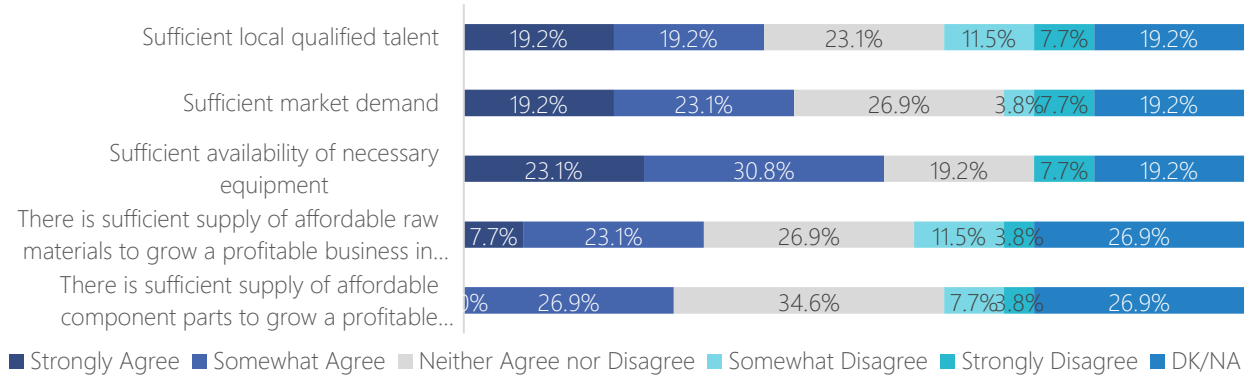


Figure 7.6 - Construction/Installation/O&M firms' assessment of supply chain for profitable business growth

One-third (35 percent) of the surveyed firms report some business challenges arising from OSW policies to date, while 42 percent somewhat or strongly agree that permitting delays have impacted their ability to grow a profitable business in the industry. One executive called for "predictable, stable demand for services."

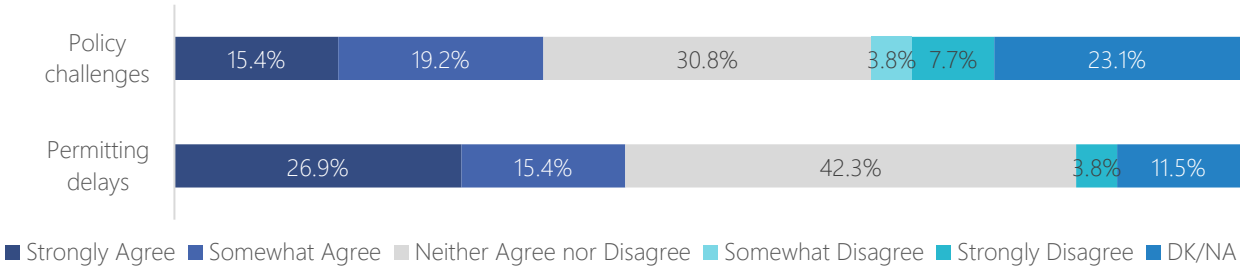


Figure 7.7 - Challenges inhibiting OSW industry growth for Construction/Installation/O&M firms

7.3 Primary Supply Chain

7.3.1 Manufacturing and Fabrication Services

Seventy-eight (78) firms primarily operate in Manufacturing and Fabrication Services, employing an estimated 4,900 workers. Among the 34 firms that completed the survey, half offer machining services; this is trailed by Milling and Welding services (38 percent of firms each).

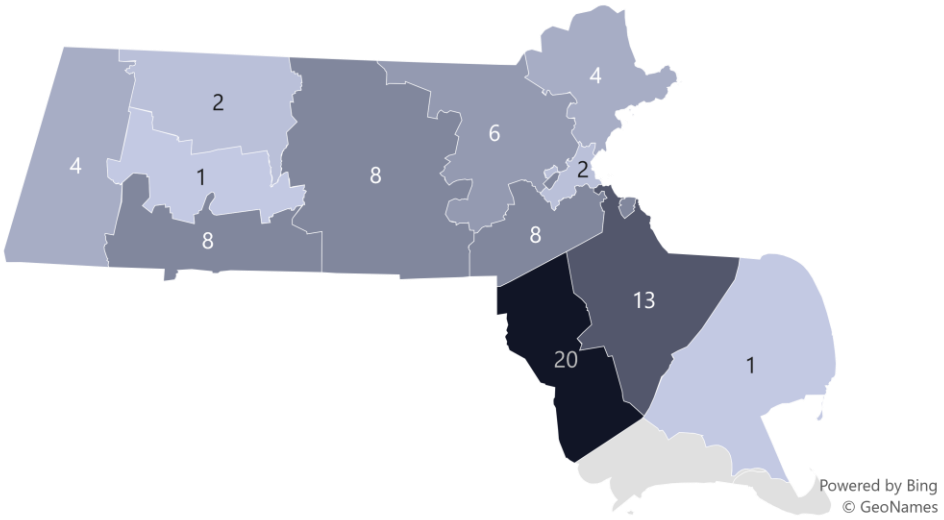


Figure 7.8 - Primary Manufacturing/Fabrication firms by county

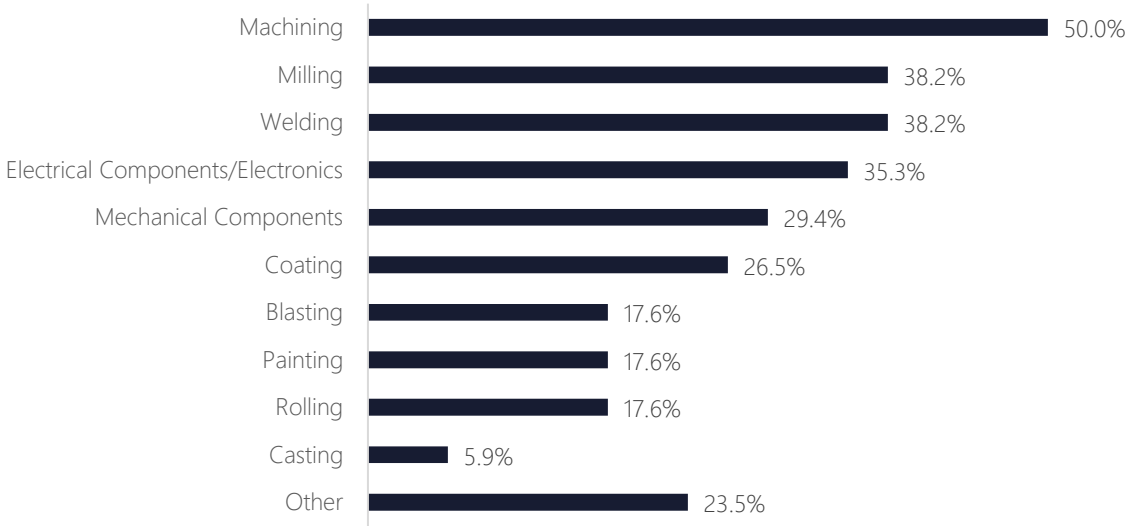


Figure 7.9 - Share of Manufacturing/Fabrication firms operating within each subsector

The surveyed firms are largely interested participating in the offshore wind industry, with 58 percent strongly agreeing to being interested in OSW business opportunities. Most firms report having goods and/or services that can be used by the OSW industry (55 percent strongly agree and 26 percent agree), but roughly one-third (30 percent) agree or strongly agree to needing significant capital investments.

Among those firms that require significant capital investment, 86 percent report they are either very likely (43 percent) or somewhat likely (43 percent) to make the necessary investments – the remaining 14 percent were unable to answer. Twenty-nine (29) percent have already estimated the approximate capital required.

Among the six remaining firms very or somewhat likely to make the required investments, two expect to be fully prepared to meet industry needs in less than 6 months, two expect it to take more than 6 months but less than a year, while the final two expect it to take more than a year. Interviews revealed a need, especially among small businesses, for industry specifications around needed parts and needed materials testing. As one firm put it: "If we are going to need new equipment, we're going to need to know the exact needs.... We don't have the time to figure everything out ourselves."

One third of the surveyed firms (35 percent) agree or strongly agree that their staff would need additional training to serve the OSW industry, with another quarter (26 percent) neither agreeing nor disagreeing. In interviews, these firms

typically elaborated that their employees were sufficiently trained in the necessary equipment and processes but that they anticipate developers wanting specific safety or materials certificates, especially around marine technologies.

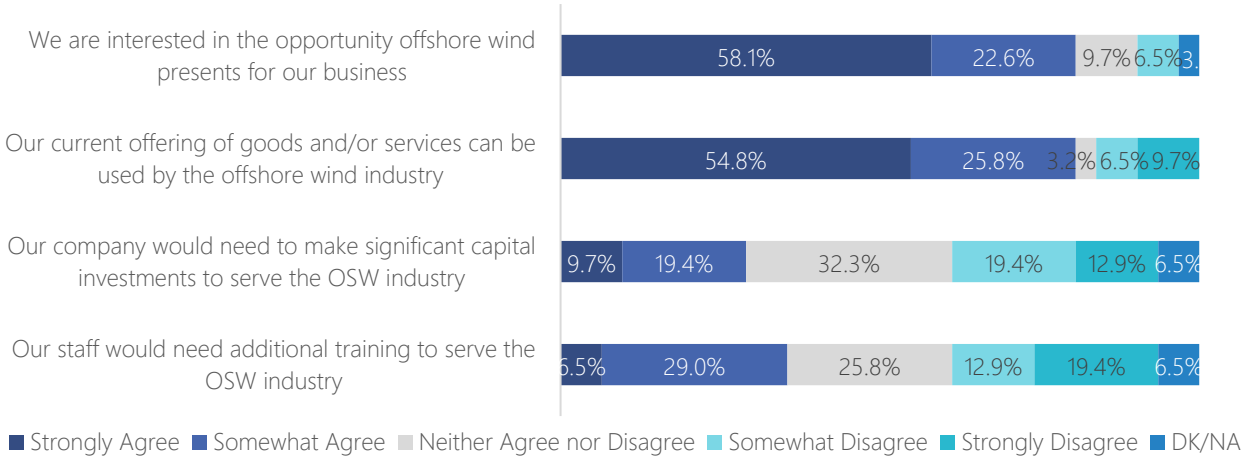


Figure 7.10 - Interest/capabilities of Manufacturing/Fabrication firms in offshore wind industry

Across the supply chain, Manufacturing and Fabrication firms are generally optimistic about the state of the local supply chain. One mentioned talent concern was the impact of rising adjacent industry wages on local small businesses' ability to compete for talent.

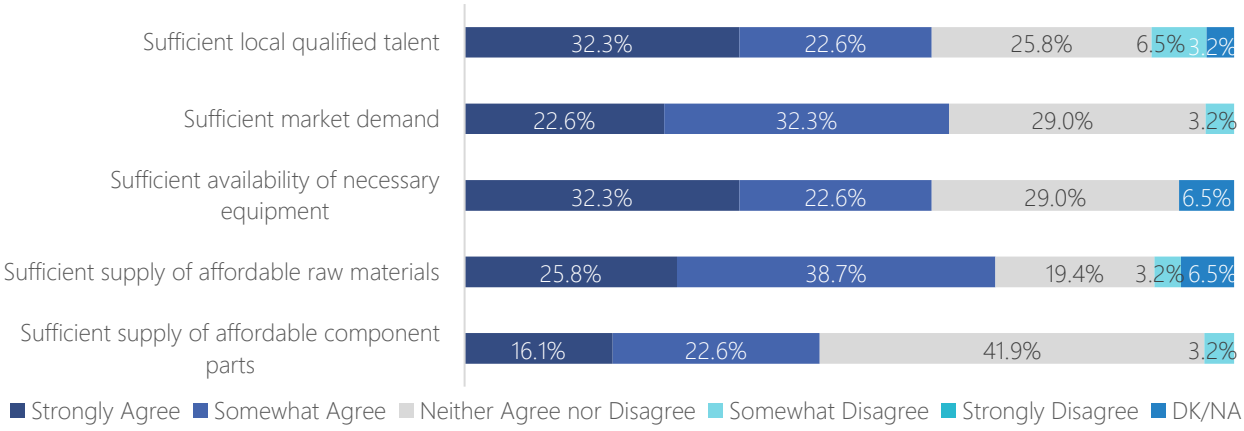


Figure 7.11 - Manufacturing/Fabrication firms' assessment of supply chain for profitable OSW business growth

Manufacturing and Fabrication firms, especially compared to their counterparts, are less aware of policy or permitting impacts on their ability to grow a profitable business in the OSW industry. Over a quarter of firms responded with "don't know" or "not applicable" to the impact of policy challenges and permitting delays (26 percent to each).

Rather, mentioned difficulties include a lack of knowledge of industry needs, who to connect with, the size of the industry, and the current industry timelines. As one firm explained in interview, "We need developers to just list out all the fabricating and manufacturing projects… [and] provide the price in Europe to give us a sense of proportion." They added, "We need to know scale of the economy in order to start building out our facilities."

Another industry executive notes that small businesses do not have a team able to research and outreach to emerging industries: "We need a list of projects and contact. Cold calling sucks, but warm calling would be helpful… something to get us started."

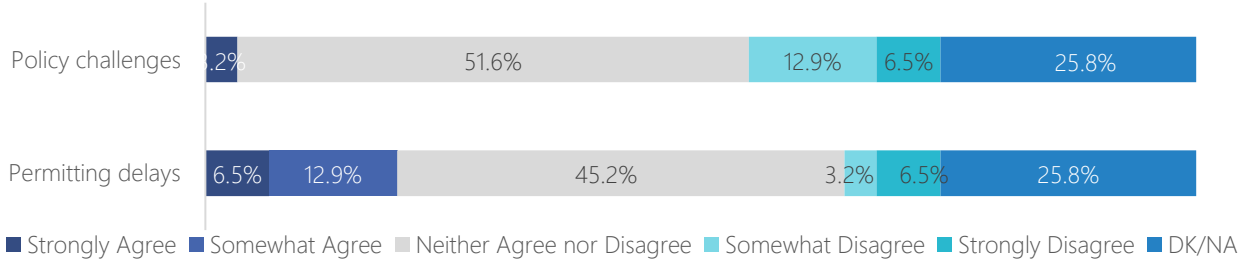


Figure 7.12 - Challenges inhibiting OSW industry growth for Manufacturing/Fabrication firms

Manufacturing and Fabrication firms were also asked about annual revenue attributed to the listed subsectors; over half (53 percent) of the surveyed firms report revenue below $5 million.

Almost all (93 percent) of Manufacturing/Fabrication respondents report that their firm currently has excess production capacity. Most of the firms (46 percent) report the ability to produce 20 to 30 percent more widgets without requiring further capital investments.

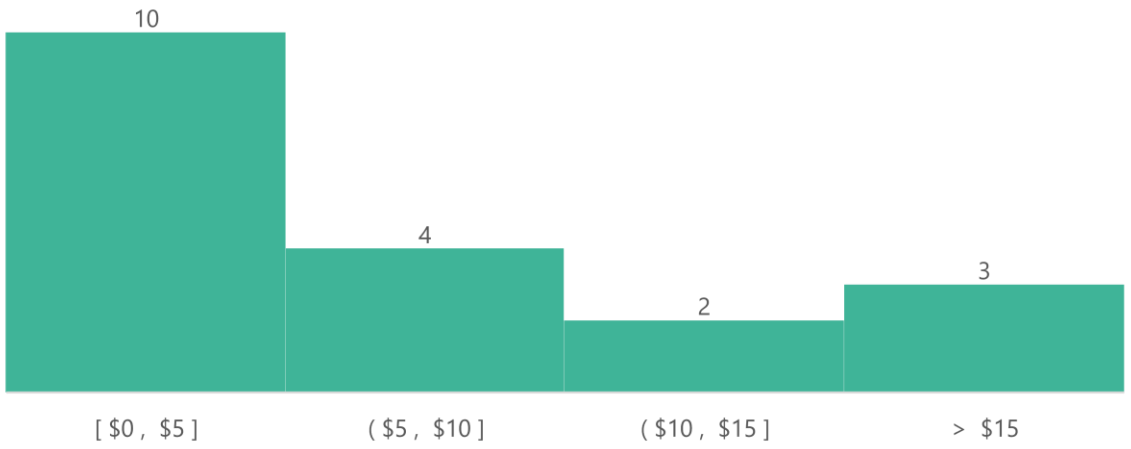


Figure 7.13 - Firms by annual Manufacturing/Fabrication revenue (in millions of dollars)

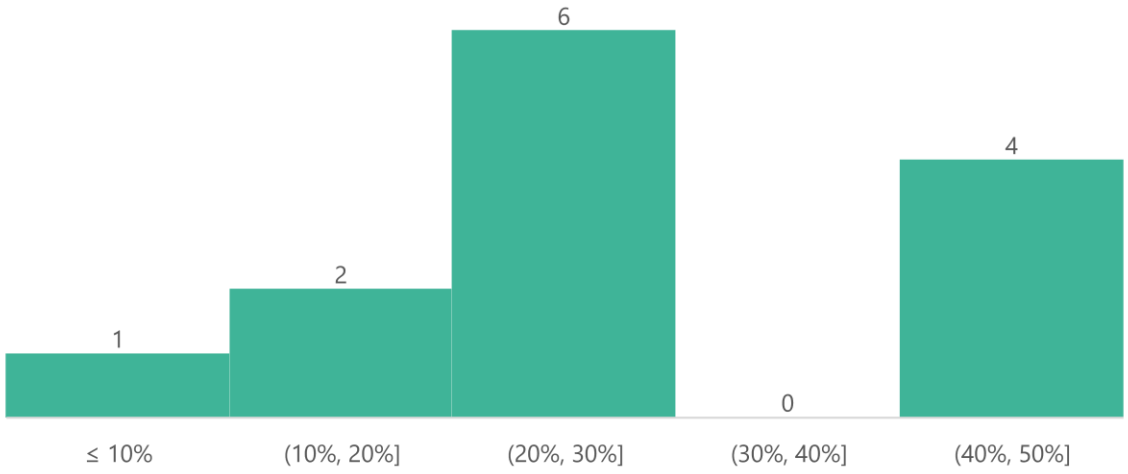


Figure 7.14 - Manufacturing/Fabrication firms by excess production capacity (as share of current production)

Manufacturing and Fabrication Firms were asked what share of their supplies/services come from inside the state, outside the state, and outside the country. The respondents report that an average of 73 percent of their suppliers and/or vendors are located in Massachusetts; less than 2 percent on average were located outside the country, including winches and specialty parts.

Figure 7.15 - Average share of Manufacturing/Fabrication firms' suppliers/vendors by location

Eleven (11) percent of Manufacturing/Fabrication firms report that *any* of their employees are affiliated with one or more unions. On average, the firms report that 20 percent of their employees were unionized.

Firms were also asked which relevant certificates their employees hold. One quarter (24 percent) report that their employees currently hold no relevant certificates. The most common certificates include Quality Control Inspector and OSHA certificates (33 and 30 percent of firms, respectively, had some employees with these certificates).

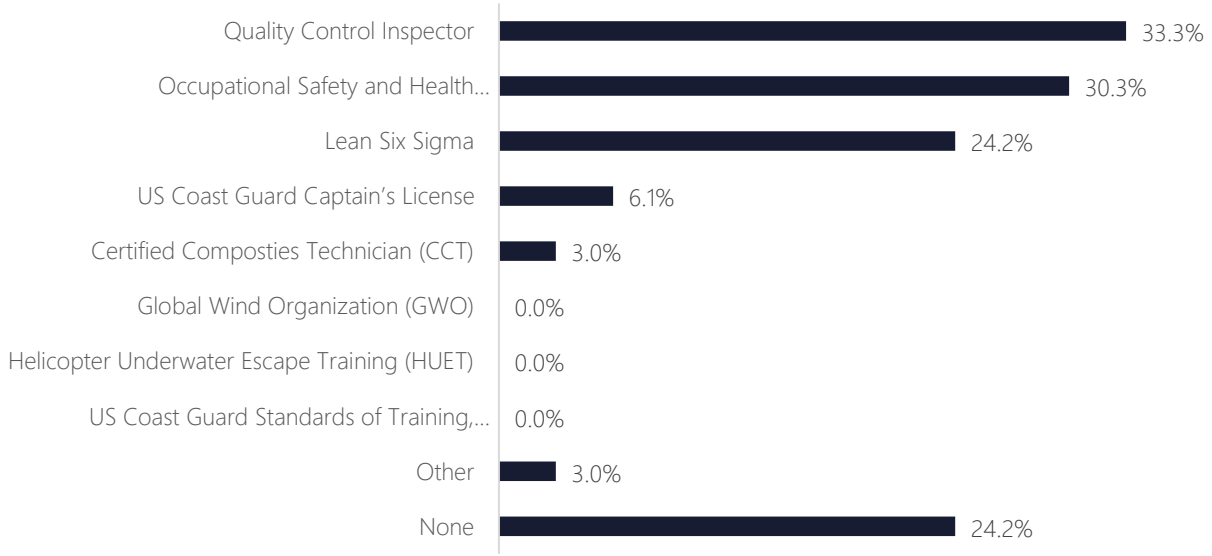


Figure 7.16 - Share of Manufacturing/Fabrication firms with employees holding various certificates

Finally, firms were asked what steps they had taken to address areas of quality, health, safety, and equity. Over half (57 percent) percent of surveyed Manufacturing and Fabrication firms are ISO-certified, nearly all of whom (53 percent overall) are certified in quality management systems (ISO 9001). Other certifications include environmental management systems (ISO 14001) and testing and calibration laboratories (ISO 17025).

Almost three in five of the surveyed firms (57 percent) report enacting policies or programs to minimize environment, health, and safety (EHS) impacts; to note, one-third refused to answer. Examples of EHS measures provided include energy conservation measures and safety trainings.

Roughly one-third (37 percent) of the firms report enacting policies or programs to foster more diversity and inclusion (D&I); half of the firms refused to answer. Cited examples include being an Equal Opportunity Employer or otherwise consciously hiring/recruiting diverse candidates.

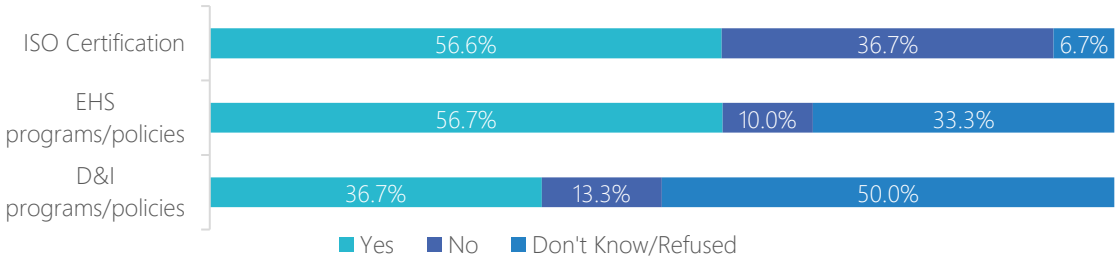


Figure 7.17 - Share of Manufacturing/Fabrication firms with ISO, EHS, and D&I measures

7.3.2 Wind Original Equipment Manufacturing (OEM)

There are only 4 known firms primarily operating as Wind OEMs in Massachusetts, employing an estimated 500 workers. Among the two that responded to the survey, one manufactures Electric Service Platforms and Substations while the other is doing 'contract management' for work likely outside of the state.

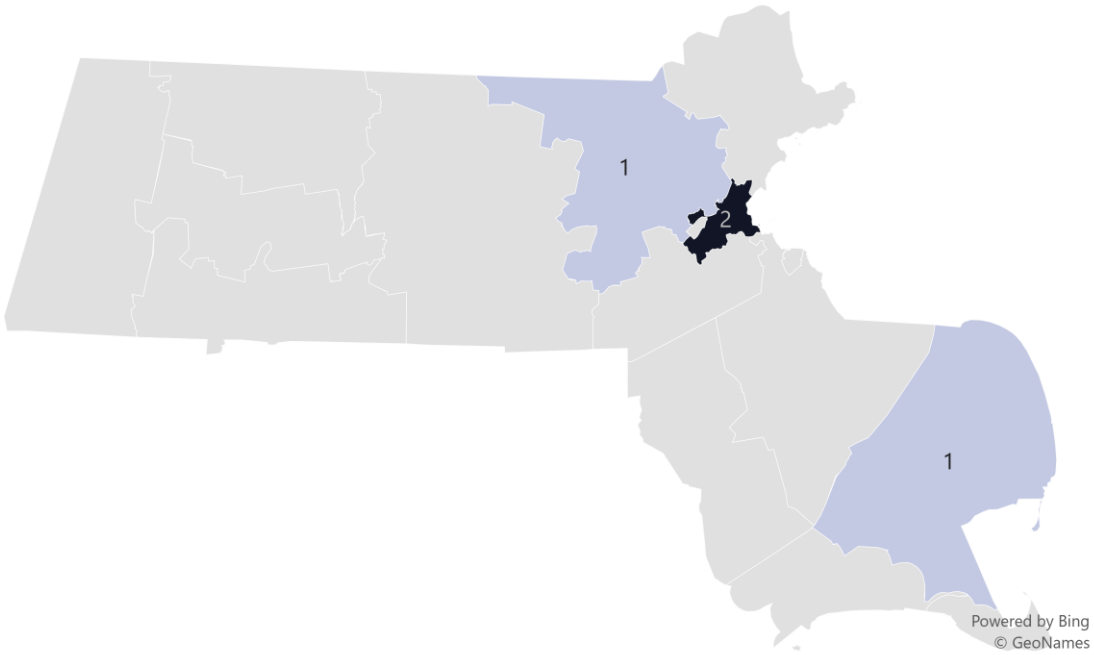


Figure 7.18 - Primary Wind OEMs by county

There was insufficient sample to report survey responses. Anecdotally, however, one of the surveyed firms reports difficulty for US-based manufacturers to compete with European OEMs. "As much as the developers, ESP fabricators and OEM's claim they want to build out and support the US supply chain, I see very little of it actually happening," the executive explained. "The tendency is to stick with low price from suppliers they have established relations with over years."

7.4 Secondary Supply Chain

7.4.1 Marine Facilities, Transport, Logistics, and Safety

Twenty-five (25) firms primarily operate in the Marine Facilities, Transport, Logistics, and Safety sector, collectively employing an estimated 1,000 workers.

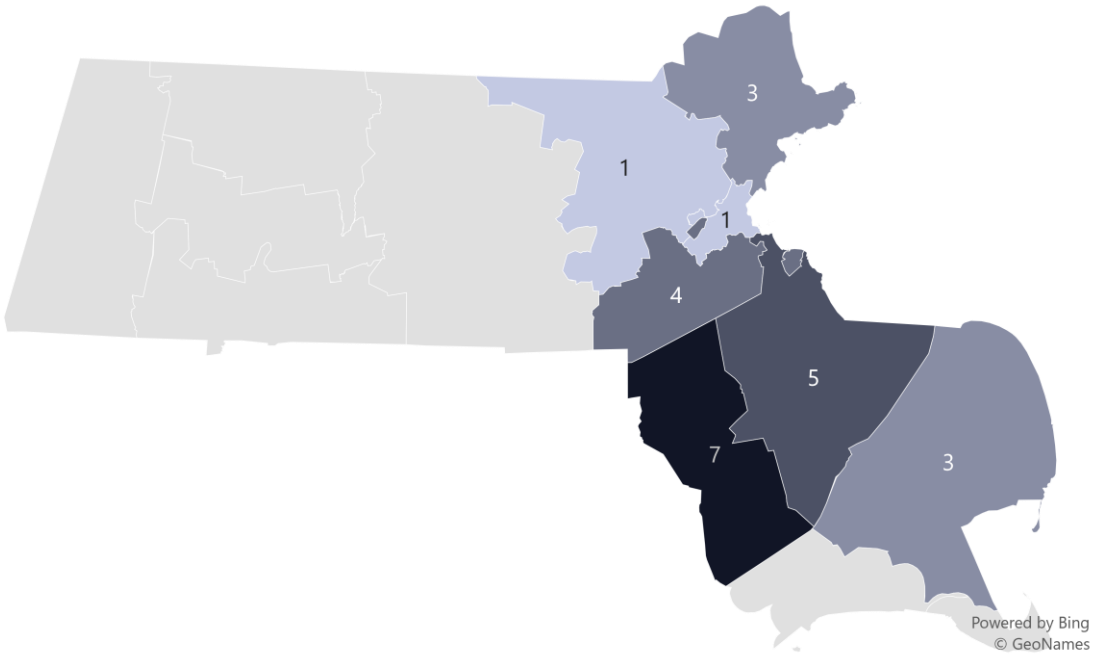


Figure 7.19 - Primary Marine Transport/Logistics/Safety firms by county

Among the 16 firms that completed the survey, the most common services are Marine Logistics (offered by 50 percent of firms) and Crew Transport Vessels (44 percent). In general, the survey revealed greater need to network in the state's existing marine industries. Despite no surveyed firms offering ship and boat building or fuel dealership services, for example, there are 40 and 446 firms in Massachusetts operating in these services, respectively.

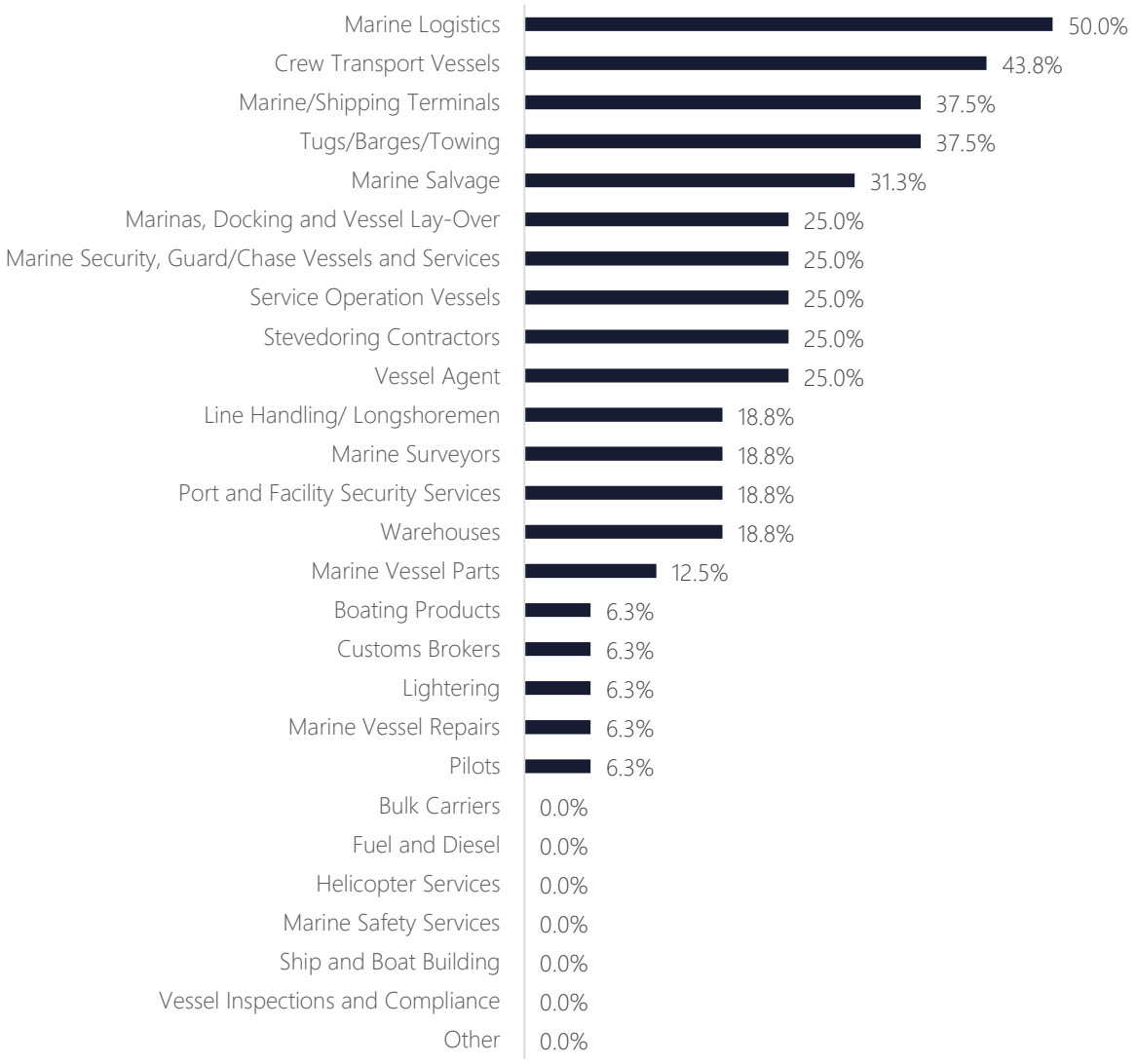


Figure 7.20 - Share of Marine Transport/Logistics/Safety firms operating within each subsector

None of the surveyed firms report a lack of interest participating in the offshore wind industry, with 88 percent strongly agreeing to being interested in OSW business opportunities. Most firms report having goods and/or services that can be used by the OSW industry (81 percent strongly agree), but nearly half (44 percent) somewhat agree or strongly agree to needing significant capital investments.

Two-thirds of the surveyed firms (68 percent) agree that their staff would need additional training to serve the OSW industry.

Figure 21.

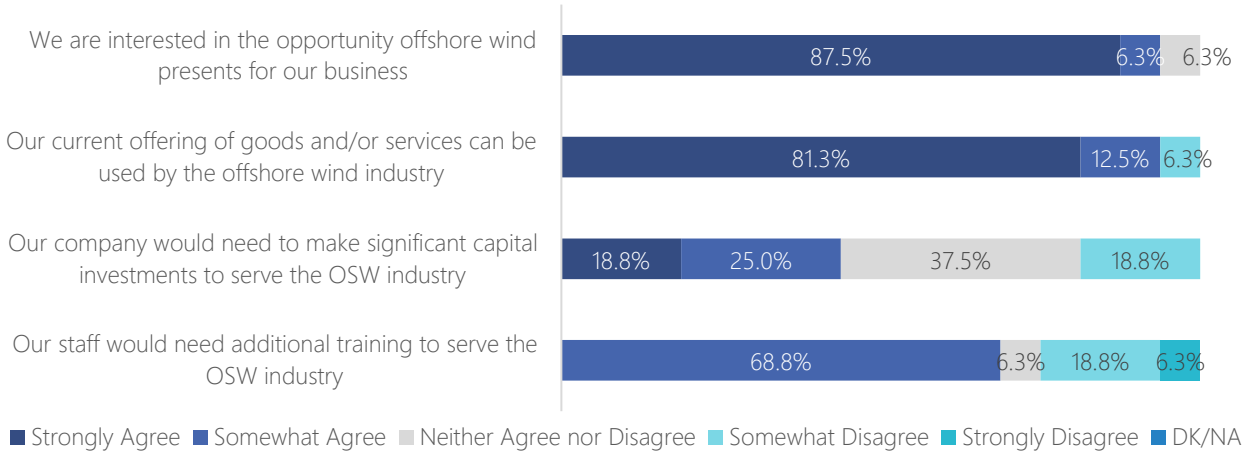


Figure 7.22 - Interest/capabilities of Marine Transport/Logistics/Safety firms in offshore wind industry

Most Marine Transport/Logistics/Safety firms find sufficient local qualified talent, market demand, and necessary equipment to grow a profitable business in the OSW industry (69 percent, 89 percent, and 56 percent agree, respectively). However, the firms were significantly less confident in sufficient supply of affordable raw materials and component parts (31 percent and 36 precent agree, respectively).

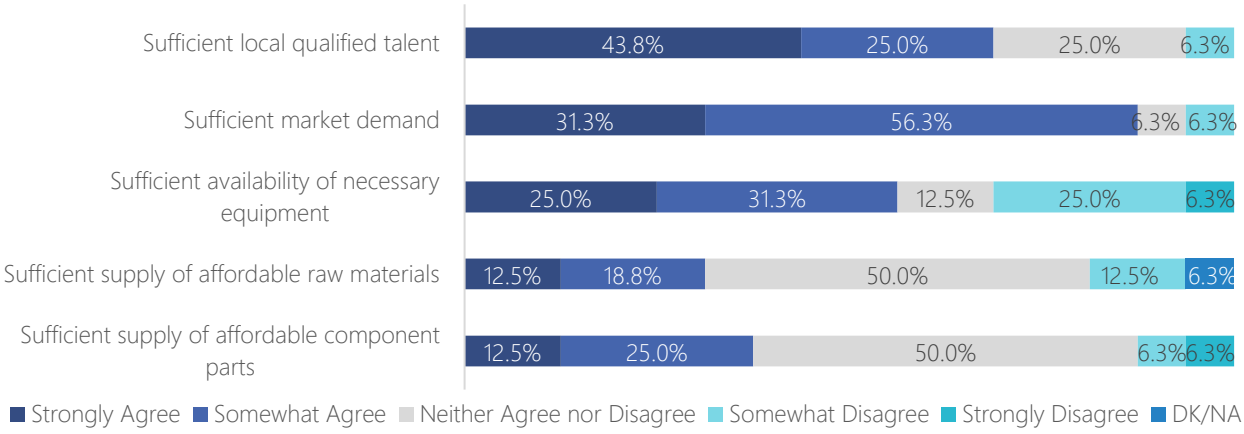


Figure 7.23 - Marine Transport/Logistics/Safety firms' assessment of supply chain for profitable OSW growth

Marine Transport/Logistics/Safety firms have found policies and permitting delays to date impact their ability to grow a profitable business in the OSW industry. Many firms report that postponed work has decreased industry confidence. As one executive put it: "Permitting uncertainty creates too much risk to make investments." Another firm reports that they "need a strong pipeline of projects" to justify investments and participation.

One firm expressed that inconsistency of safety/quality standards enforcement have decreased competitiveness. They report going through an extensive safety and insurance process early in the industry development but now seeing fishing boats involved in projects that have not been held to the same standards.

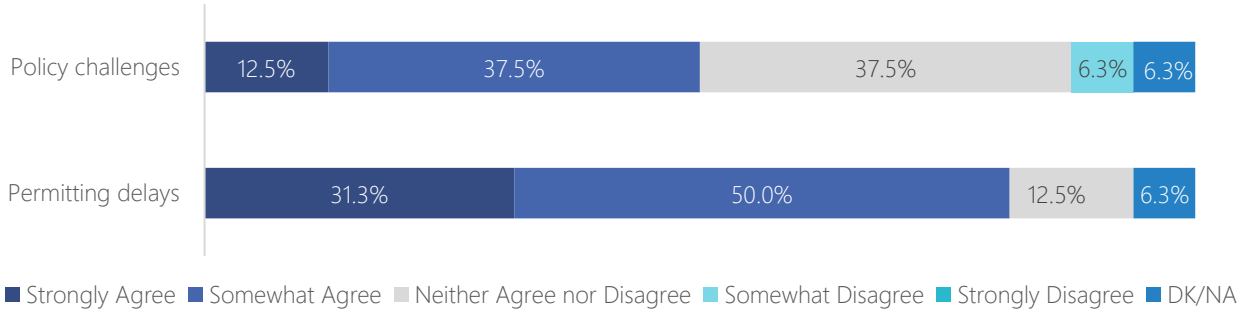


Figure 7.24 - Challenges inhibiting OSW industry growth for Marine Transport/Logistics/Safety firms

Marine Facilities, Transport, Logistics, and Safety firms report that an average of 60 percent of their suppliers and/or vendors are located in Massachusetts, with almost 8 percent located outside the country.

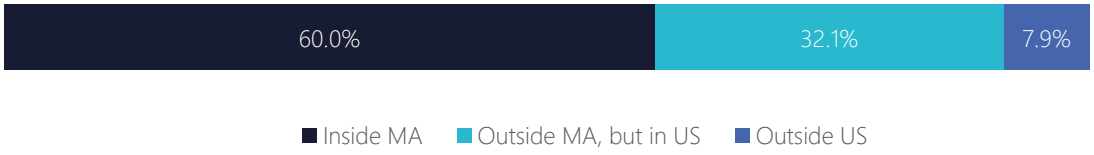


Figure 7.25 - Average share of Marine Transport/Logistics/Safety firms' suppliers/vendors by location

Eleven (11) percent of firms report that *any* of their employees are affiliated with one or more unions. On average, the firms report that 41 percent of their employees were unionized.

Meanwhile, half of surveyed firms report that at least one employee holds certification in OSHA, US Coast Guard STCW, and/or US Coast Guard Captain's Licensure.

Figure 26.

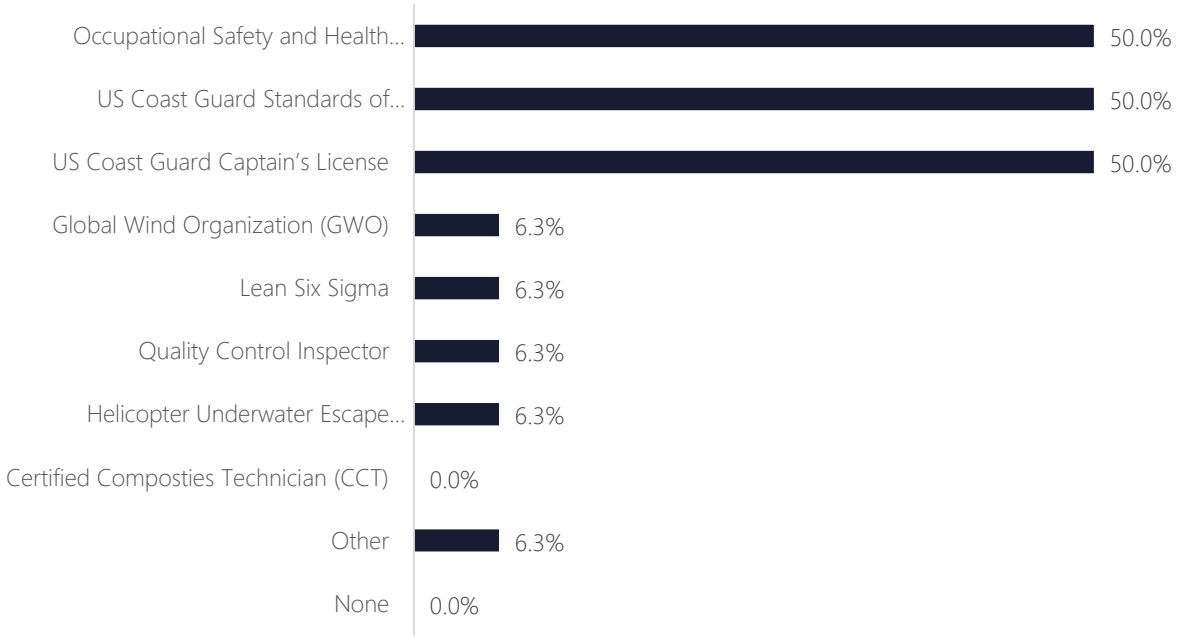


Figure 7.27 - Share of Marine Transport/Logistics/Safety firms employing workers with relevant certificates

One-third of surveyed Marine Facilities, Transport, Logistics, and Safety firms are ISO-certified, with 27 percent certified in quality management systems (ISO 9001). One-fifth of the firms are certified in environmental management systems (ISO 14001) and/or ships and marine technology/ offshore wind energy/ port and marine operations (ISO 29400).

Roughly half of the surveyed firms (47 percent) report enacting policies or programs to minimize EHS impacts; to note, one-third refused to answer. Examples of EHS measures provided include hiring a full-time EHS employee and receiving "Green Marine Certification.'

Forty (40) percent of the firms report enacting policies or programs to foster more diversity and inclusion; another 40 percent of the firms refused to answer.

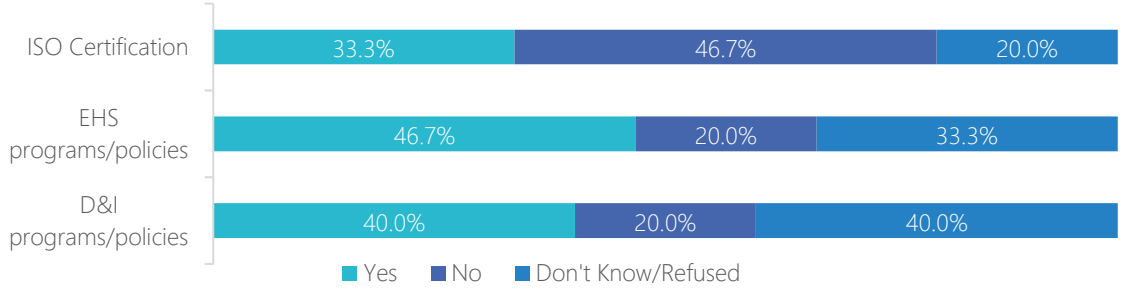


Figure 7.28 - Share of Marine Transport/Logistics/Safety firms with ISO, EHS, and D&I measures

7.4.2 Equipment, Supplies, Materials, and Associated Services

Forty-nine (49) firms primarily operate in Equipment, Supplies, Materials, and Associated Services; employing an estimated 2,300 workers.

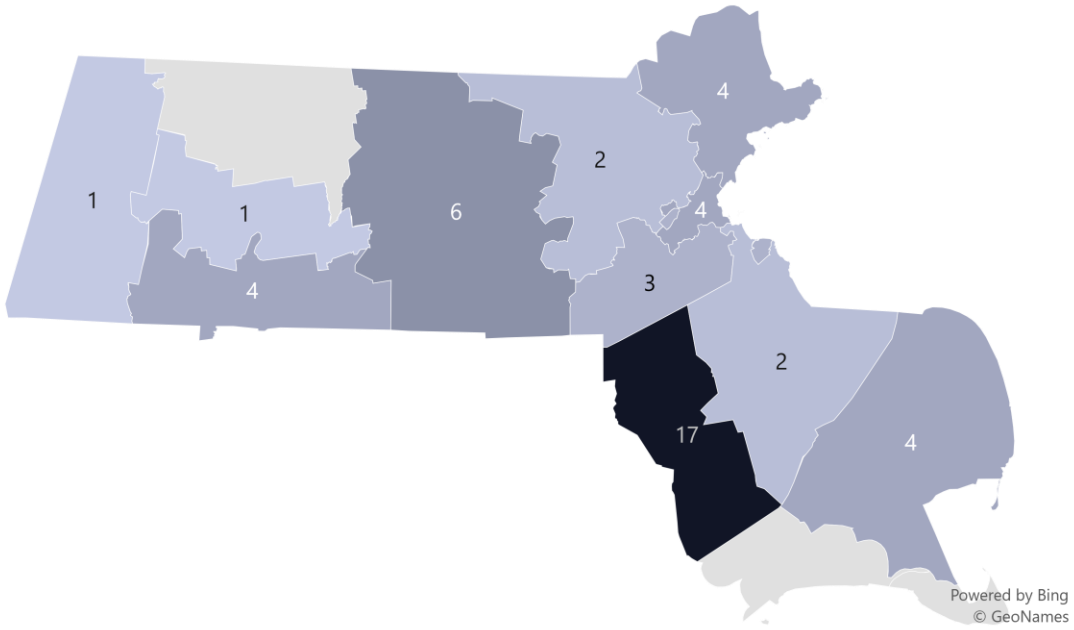


Figure 7.29 - Primary Equipment/Supplies/Materials firms by county

Among the 17 firms that completed the survey, 24 percent supply Lifting Appliances, Rope, Rigging, and Slings. Other services listed (41 percent of responses) include the supply of audio and video codecs, diesel generators, hydraulic components, safety equipment, and oil filtration systems.

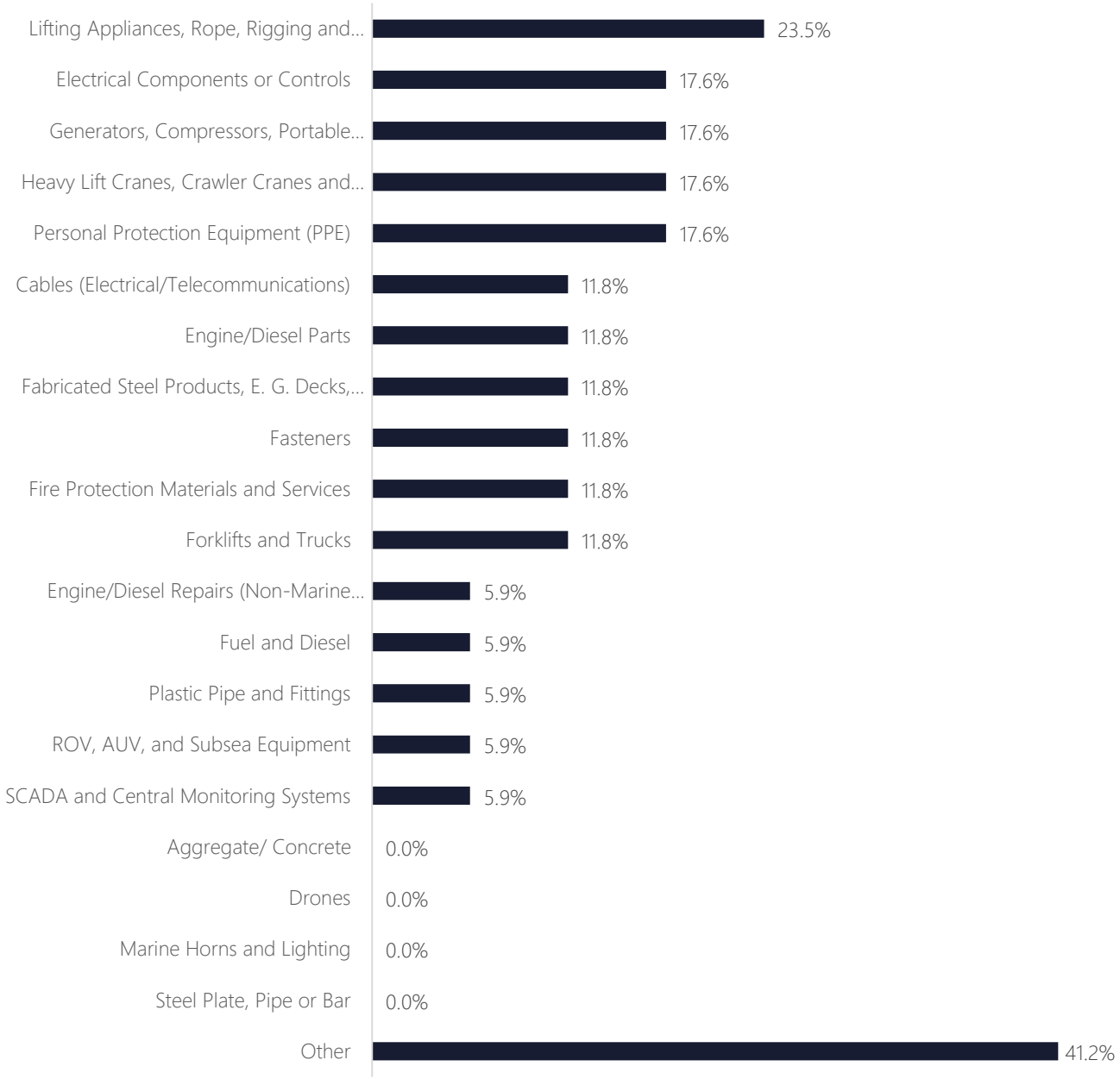


Figure 7.30 - Share of Equipment/Supplies/Materials firms operating within each subsector

None of the surveyed firms report a lack of interest in participating in the offshore wind industry, with 80 percent strongly agreeing to being interested in OSW business opportunities. Most firms report having goods and/or services that can be used by the OSW industry (84 percent strongly agree) and none expect to need significant capital investments (though nearly one-third responded "don't know/ not applicable").

Very few of the surveyed firms (11 percent) think that their staff would need additional training to serve the OSW industry.

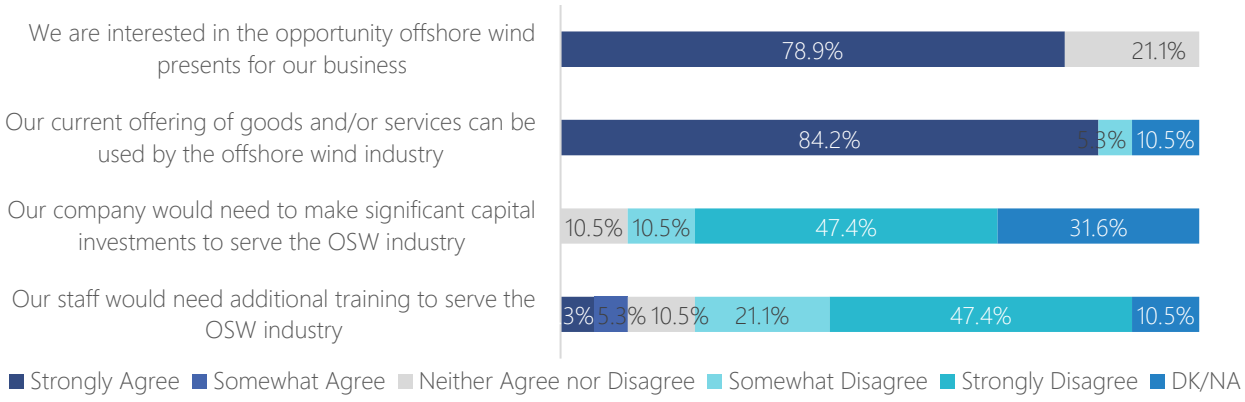


Figure 7.31 - Interest/capabilities of Equipment/Supplies/Materials firms in offshore wind industry

A significant share of Equipment, Supplies, Materials, and Associated Services firms find sufficient local qualified talent and market demand to grow a profitable business in the OSW industry (68 percent and 79 percent agree, respectively).

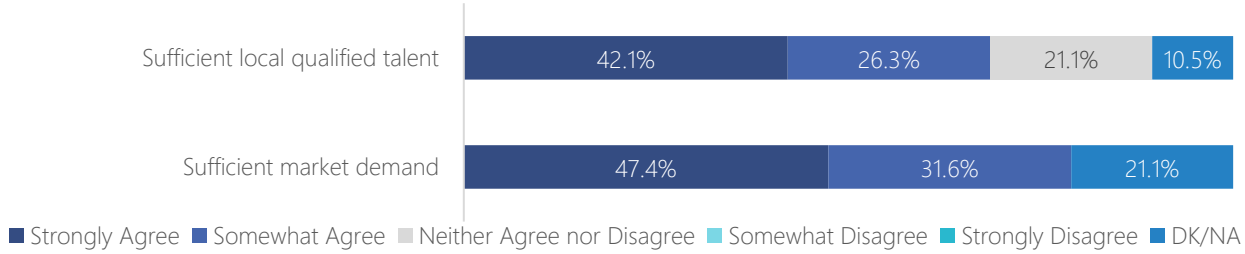


Figure 7.32 - Equipment/Supplies/Materials firms' assessment of supply chain for profitable OSW growth

Firms in this sector report mixed experiences to date with policy challenges and permitting delays impacting their ability to grow a profitable business in the OSW industry. At least one in five either did not know or did not find each of these variables applicable.

Business challenges reported include a lack of clarity on project needs and points of contact, as well as high local labor costs impacting competitiveness with out-of-state and international suppliers. "We have to compete on our quality, because making it in Massachusetts on hourly rate alone is more expensive than other places," explained one executive, noting high local competition for moderately skilled labor (southeast Massachusetts) is driving up wages.

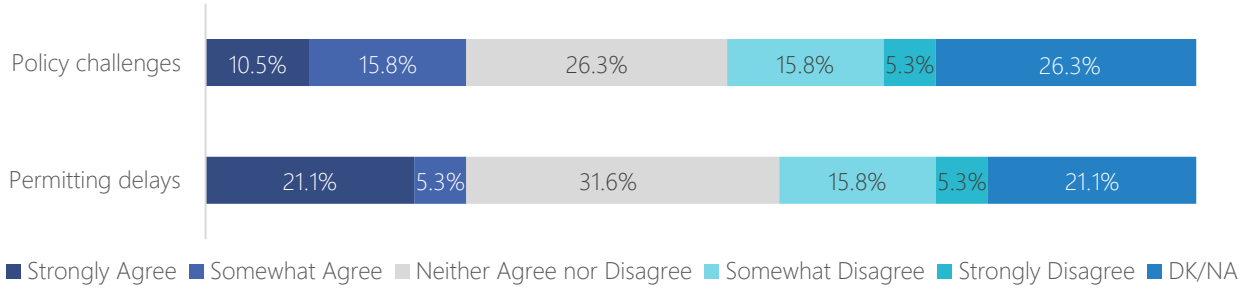


Figure 7.33 - Challenges inhibiting OSW industry growth for Equipment/Supplies/Materials firms

7.5 Development And Professional Services

7.5.1 Environmental, Engineering, Geological, & Testing Services

Forty-six (46) firms primarily operate in Environmental, Engineering, Geological, & Testing Services; employing an estimated 4,200 workers.

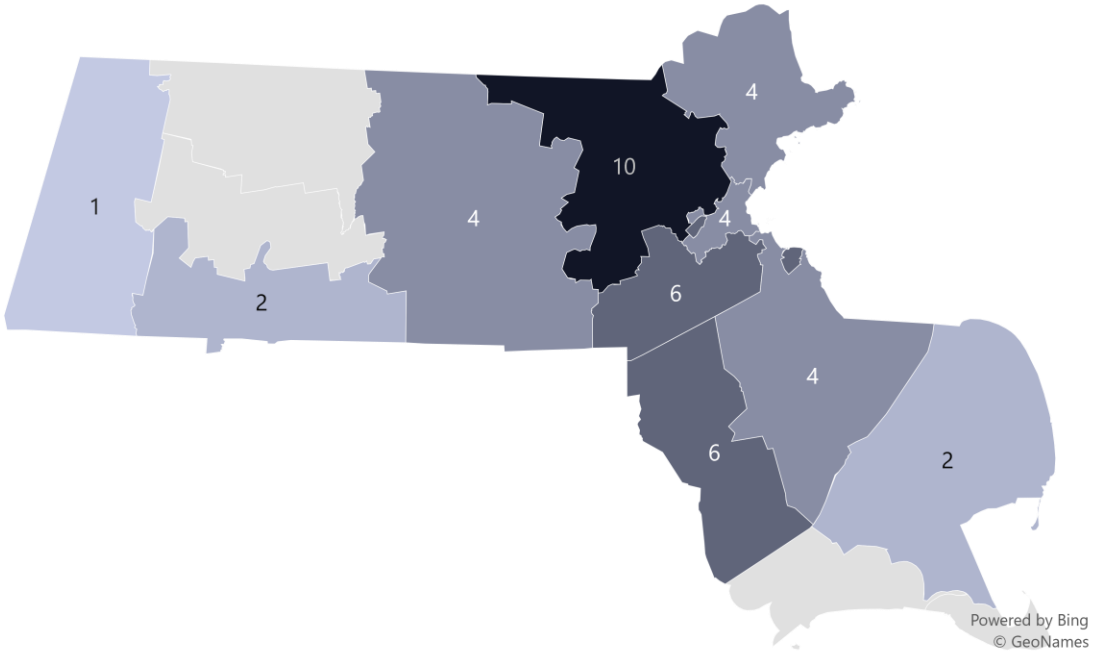


Figure 7.34 - Primary Enviro/Engineering/Geo/Testing firms by county

Among the 28 firms that completed the survey, the most common services are Environmental Permitting, Assessments, Analysis and Impact Statements/Reports and Environmental Engineering (offered by 84 and 80 percent, respectively). Only two firms claimed to offer Biological and Marine Life Surveys and Studies.

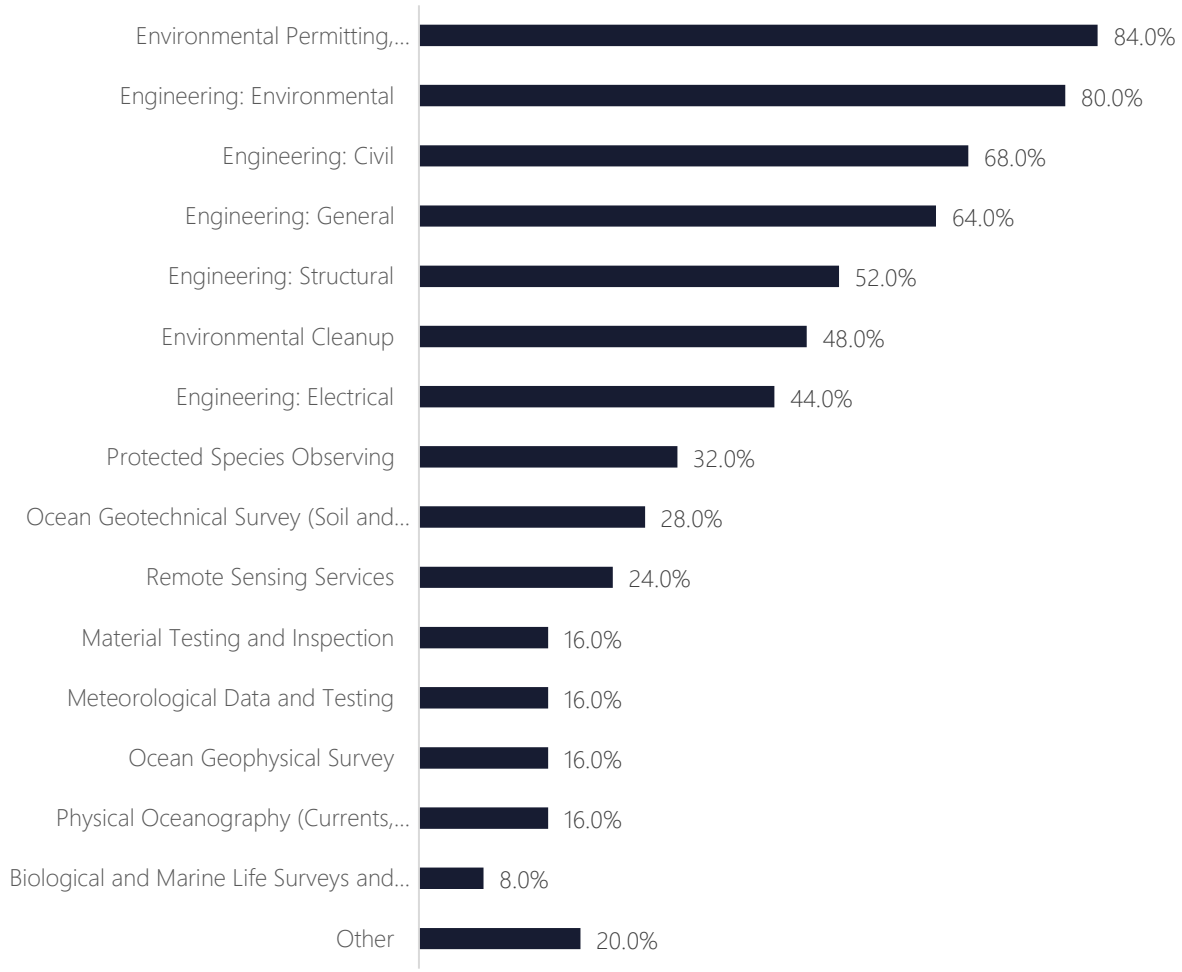


Figure 7.35 - Share of Enviro/Engineering/Geo/Testing firms operating within each subsector

Nearly all of the surveyed firms in Environmental, Engineering, Geological, & Testing Services (96 percent) report both an interest in participating in the offshore wind industry and having goods and/or services that can be used by the OSW industry. Only one-in-five firms (20 percent) see a need to make significant capital investments.

More than a third of the surveyed firms (36 percent), however, think that their staff would need additional training to serve the OSW industry. Interviews revealed that this training includes marine safety certification (for on-site work), with at least one reporting both difficulty finding available training and inconsistency in safety rigor across projects.

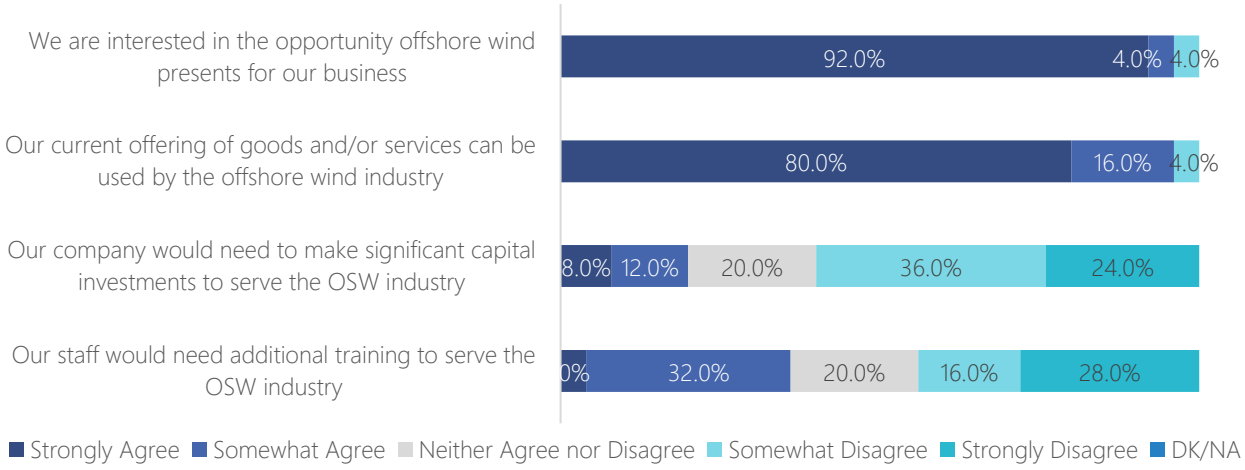


Figure 7.36 - Interest/capabilities of Enviro/Engineering/Geo/Testing firms in offshore wind industry

Most firms find there to be sufficient local qualified talent and market demand to grow a profitable business in the OSW industry (64 percent and 60 percent agree, respectively).

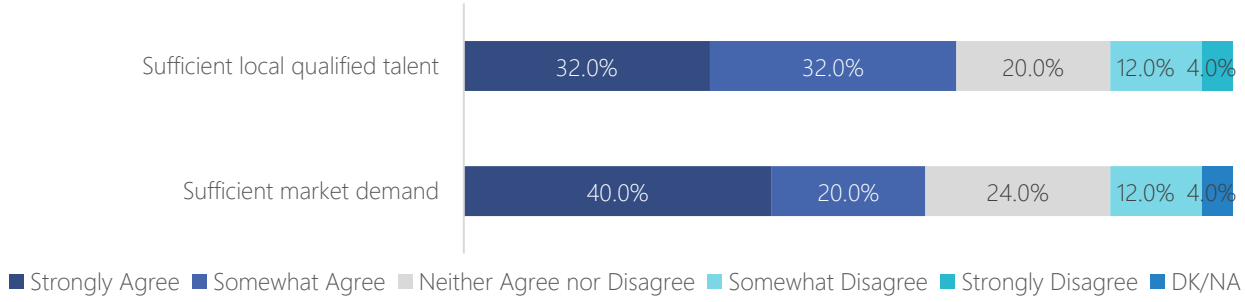


Figure 7.37 - Enviro/Engineering/Geo/Testing firms' assessment of supply chain for profitable OSW growth

Environmental, Engineering, Geological, & Testing Services firms generally found policy challenges have impacted their ability to grow a profitable business in the OSW industry (48 percent agree). Interviews revealed difficulty keeping up with rapidly evolving policies (particularly across multiple states) and a limited emphasis on local content hampering competitiveness.

Permitting delays present a large financial risk for firms entering the industry (80 percent agreement), especially for those who need to contract out services and vessels. Interviews did reveal, however, that firms are optimistic that the new federal administration will greatly reduce future permitting delays.

Other business challenges reported include difficulty for small firms to break into the market without relationships with developers and Tier 1 suppliers, difficulty finding other firms to partner with, difficulty competing against universities to complete technical studies, and difficulty bringing experienced European hires to the US due to COVID-19 and immigration regulations.

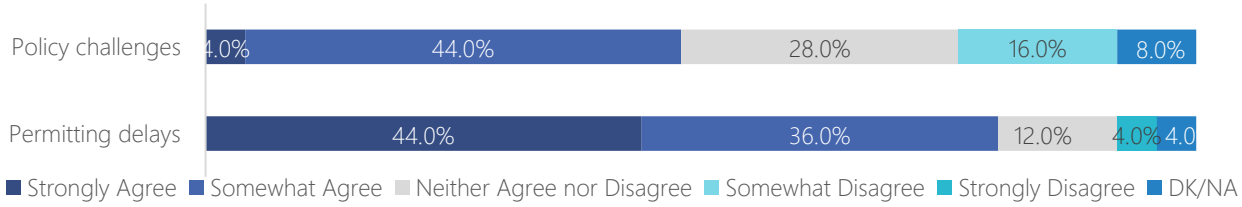


Figure 7.38 - Challenges inhibiting OSW industry growth for Enviro/Engineering/Geo/Testing firms

7.5.2 Professional and Consulting Services

One hundred forty-nine (149) firms primarily operate in Professional and Consulting Services, collectively employing an estimated 4,600 workers. These firms were not asked to specify a subsector.

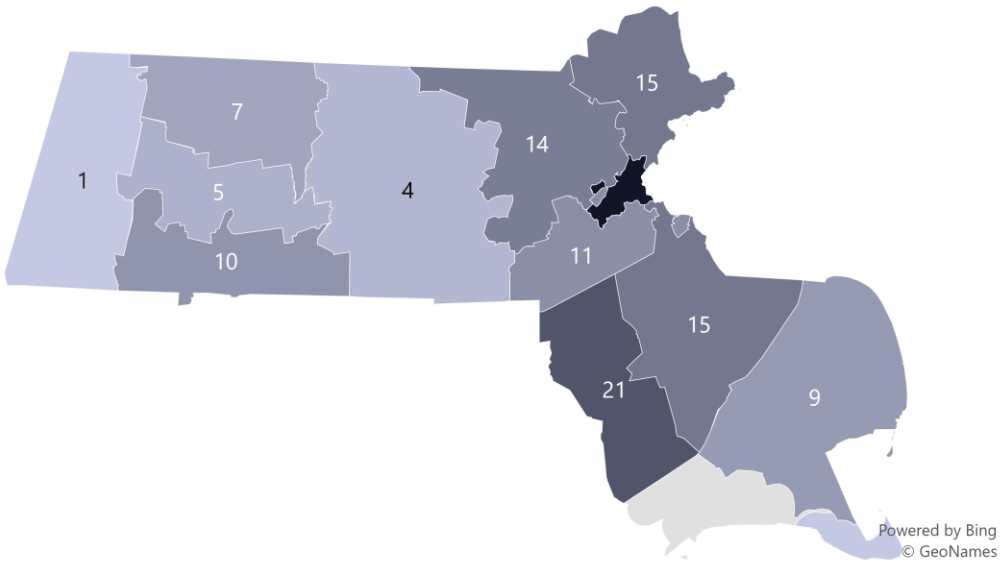


Figure 7.39 - Primary Professional/Consulting firms by county

None of the surveyed firms report a lack of interest participating in the offshore wind industry, with 79 percent strongly agreeing to being interested in OSW business opportunities. Most firms report having goods and/or services that can be used by the OSW industry (74 percent strongly agree), and very few (9 percent) agree to needing significant capital investments.

A quarter of the surveyed firms (24 percent) agree that their staff would need additional training to serve the OSW industry. This, according to interviews, includes the possibility of needing offshore safety training for on-site work.

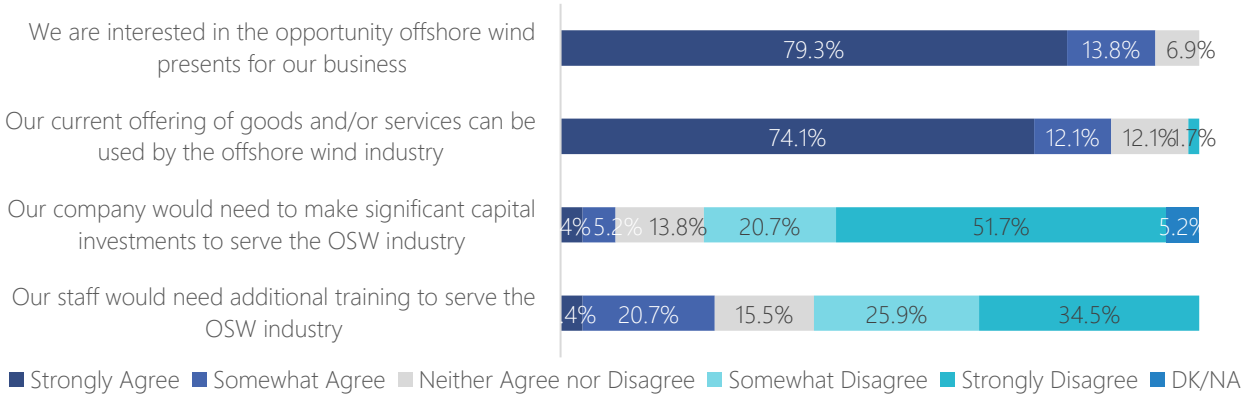


Figure 7.40 - Interest/capabilities of Professional/Consulting firms in offshore wind industry

Most Professional/Consulting firms find sufficient local qualified talent and market demand to grow a profitable business in the OSW industry (59 percent and 72 percent agree, respectively).

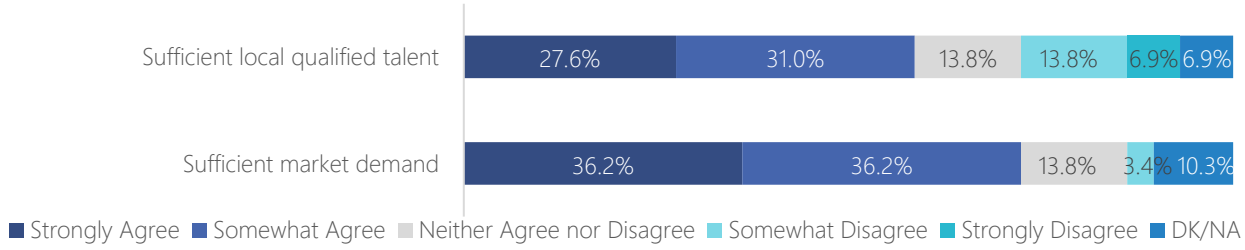


Figure 7.41 - Professional/Consulting firms' assessment of supply chain for profitable OSW growth

Professional/Consulting firms have found policies and, especially, permitting delays to date impact their ability to grow a profitable business in the OSW industry (50 percent and 71 percent agree, respectively).

On the policy side, firms report that contracting secrecy and low local content requirements have made it difficult for smaller businesses to compete with those with existing relationships with developers. "Massachusetts has been going with a low-cost approach, with local content not as strong a criterion as, say, New York… This results in companies choosing to go to New York and not Massachusetts… [while some] just put a front-end office in Massachusetts," stated one executive, noting that early industry expectations included strong local content requirements.

Secrecy comments again revolved around difficulty breaking into the industry without pre-existing relationships with contractors, especially among small businesses without staff to network or conduct industry research.

Permitting delays are particularly difficult in that extensive time and expense is allocated toward being competitive in bidding processes (including proposals and insurance), resulting in cash flow issues when developers are delayed. "We've had to pivot toward supporting other industries in order to stay in the positive," says one executive.

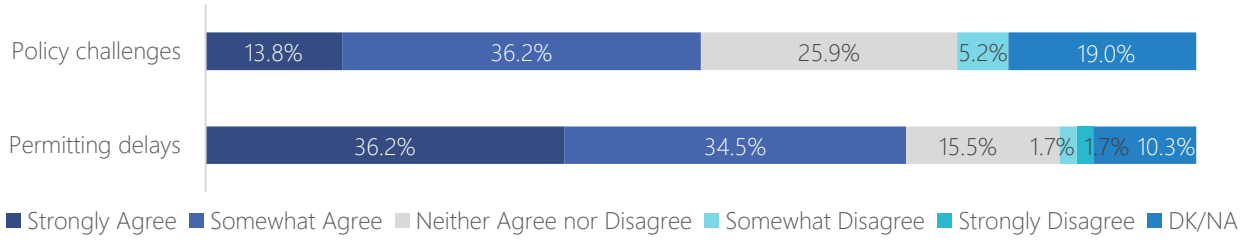


Figure 7.42 - Challenges inhibiting OSW industry growth for Professional/Consulting firms

7.5.3 Project Developers

Twelve (12) firms in Massachusetts operate primarily as Project Developers, employing an estimated 3,000 workers. Project Development includes Transmission Developers/Operators; one such firm responded to the survey.

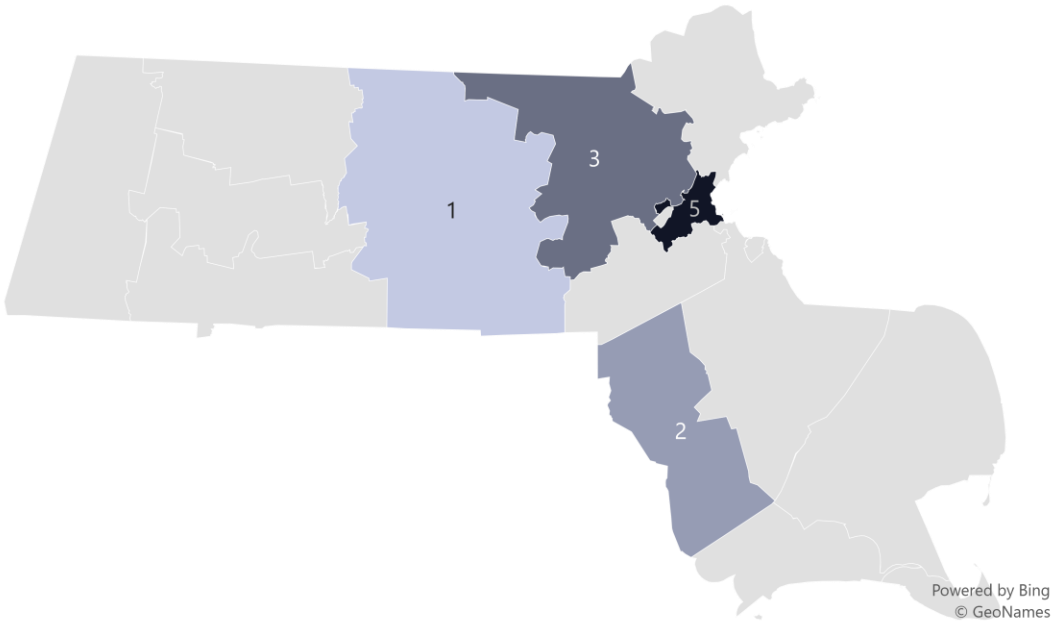


Figure 7.43 - Primary Project Development firms by county

7.6 Support Services

7.6.1 Government

There are 15 known government agencies working directly in the industry, employing an estimated 200 workers. Government organizations were not targeted in the survey outreach, nor asked to specify subsector.

One organization expressed frustration with power sales being "tied to the utilities in one stop contracting, rather than sleeving off power to benefit independent power brokers."

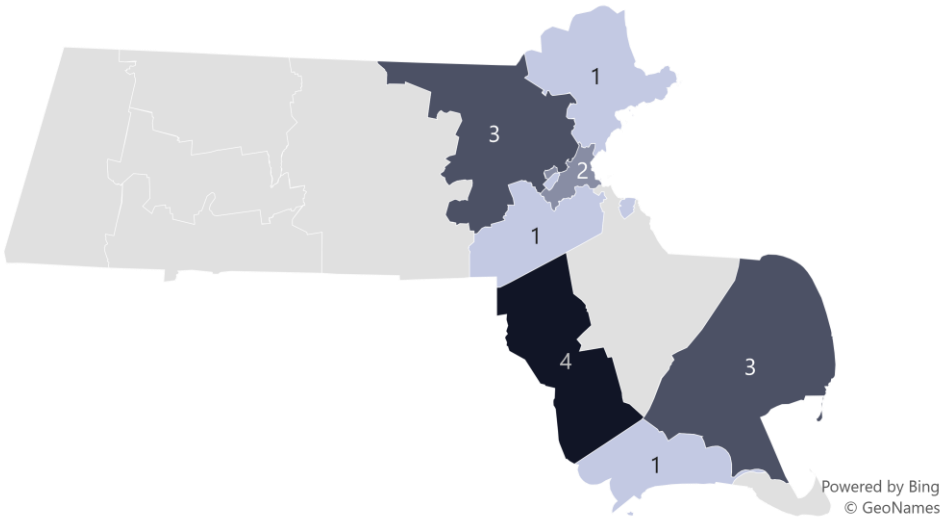


Figure 7.44 - Primary Government organizations by county

7.6.2 Trades, Labor, and Workforce Organization

There are currently 17 Trades, Labor, and Workforce Organizations involved in the offshore wind industry, employing an estimated 200 workers. Among the six firms that completed the survey, three are Workforce Providers.

Surveyed firms note training and certifications needs, as well as a need for clarity around Jones Act implications.

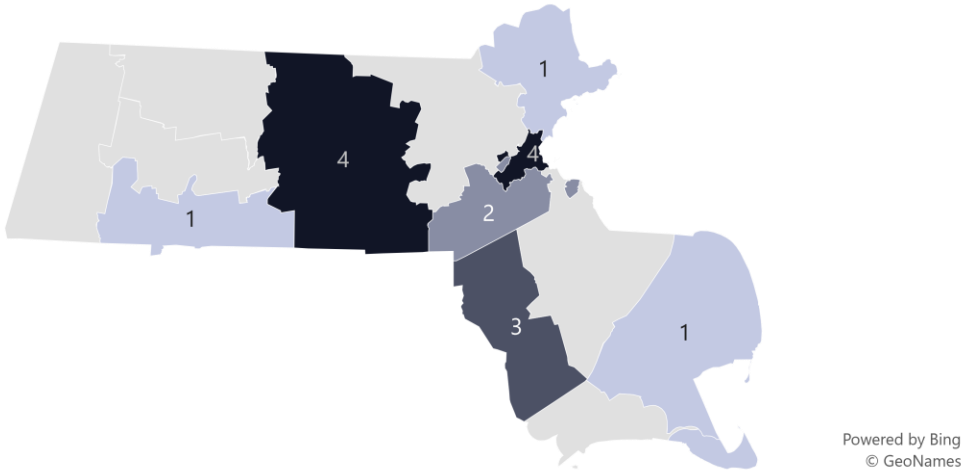


Figure 7.45 - Primary Trades/Labor/Workforce organizations by county

7.6.3 Education/Training

Twenty-one (21) firms primarily operate in the Education and Training sector, employing an estimated 6,700 workers.

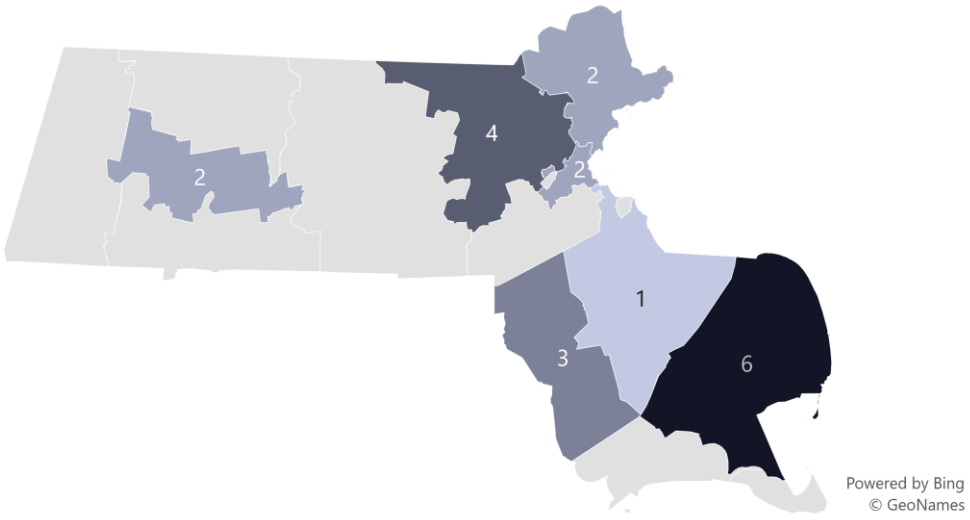


Figure 7.46 - Primary Education/Training firms by county

Among the 13 firms that completed the survey, a large share (46 percent) are college degree programs, followed by 39 percent offering Health, Safety, and Environmental Training.

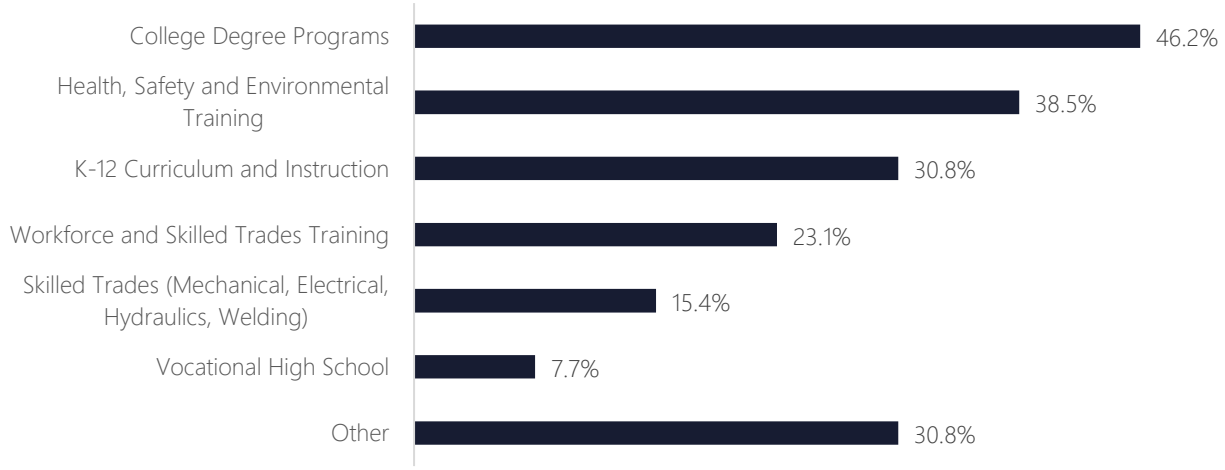


Figure 7.47 - Share of Education/Training firms operating within each subsector

7.6.4 Other

There are 17 firms known to be interested in participating in the OSW industry whose primary functions cannot be placed neatly into the aforementioned industry sectors. Examples include landscaping, water utilities, advocacy groups, and media.

These firms report similar business difficulties to other sectors, stemming from both COVID-19 and OSW permitting delays.

8 TASK C - POST-SURVEY DATABASE ANALYSIS

8.1 All Industry Sectors

An analysis was conducted to show the increase in the number of companies listed in the MassCEC Database from the time the first draft report was issued (November 2020) until now (March 2021). An itemized list of companies that were identified and contacted by BW Research for the purposes of their survey was used to record companies that registered themselves in the database after completing the survey.

There were increases in the number of companies listed in the database in all industry sectors, with major increases in some sectors where the number of companies between November of 2020 and March of 2021 more than doubled.

A visualization of the change in the contents of the MassCEC database is represented in Figure 8-1 where the contents of the database as they were in November 2020 (grey) are juxtaposed with the status of the database in March of 2021 (red) and the projected number of companies in each industry sector based on the respondents to the BW Research survey (blue).

It is important to note that companies that registered in the MassCEC database may have entered their credentials as a result of coming across the database through word of mouth, a different marketing campaign, or by other means and not a direct result of the BW Research Survey campaign.

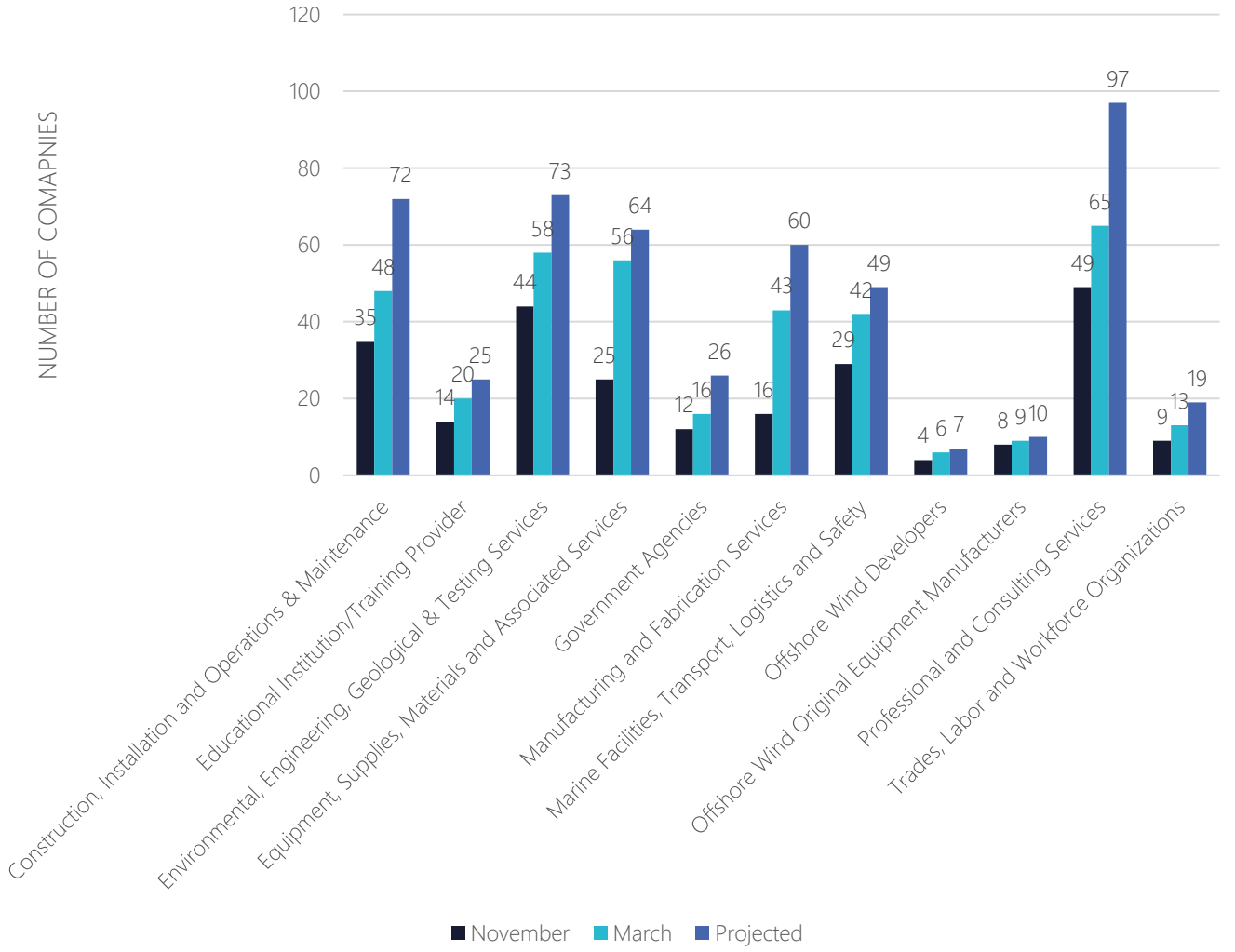


Figure 8-1 Overview of Industry Sectors

A breakdown of Figure 8-1 is presented in Table 8-1, where the total number of companies added to each industry sector along with the increase in the number of companies as a percentage of the companies that were listed in November of 2020. There was a total of 73 new entrants into the database over this time, and 23% of these companies took part in the BW Research Survey (17 companies). The participation from these 17 companies was also broken down by sector and can be seen in the final column of Table 8-1. It is important to note that there were four new companies that registered within the database and completed the BW Research Survey that indicated that the location of their business was outside of Massachusetts.

Table 8-1 Tabulated Overview of Companies in Industry Sectors

INDUSTRY SECTOR	NUMBER OF COMPANIES NOVEMBER	NUMBER OF COMPANIES MARCH	PROJECTED NUMBER OF COMPANIES	CHANGE IN NUMBER OF COMPANIES	PERCENT INCREASE	SURVEY RESPONSE FROM NEWLY LISTED COMPANIES
Construction, Installation and Operations & Maintenance	35	48	72	13	37%	31%
Educational Institution/Training Provider	14	20	25	6	43%	17%
Environmental, Engineering, Geological & Testing Services	44	58	73	14	32%	50%
Equipment, Supplies, Materials and Associated Services	25	56	64	31	124%	26%
Government Agencies	12	16	26	4	33%	50%
Manufacturing and Fabrication Services	16	43	60	27	169%	30%
Marine Facilities, Transport, Logistics and Safety	29	42	49	13	45%	31%
Offshore Wind Developers	4	6	7	2	50%	100%
Offshore Wind Original Equipment Manufacturers	8	9	10	1	13%	0%
Professional and Consulting Services	49	65	97	16	33%	31%
Trades, Labor and Workforce Organizations	9	13	19	4	44%	75%

8.2 Construction, Installation, and Operations/Maintenance Services

Some of the interesting takeaways that have been made from the data related to companies in the Construction, Installation and O&M Sector are related to the specific companies that have recently listed themselves in a few of the sub-sectors. As it pertains to the Wind Turbine Generator Installation and Jacket Installation sub-sectors there was an increase of an additional two companies in both areas. The capabilities required to take part in these portions of the supply chain are vast and there are few companies based in the US at this point that could compete with other companies around the world in these areas. We investigated the companies in these sub-sections and found that while some of the capabilities align with what is needed for these sub-sectors, such as pile driving for jacket installation and lifting capabilities for wind turbine generator (WTG) installation, there would need to be a major uptick in scale to take part in these portions of the OSW supply chain. Massachusetts has several companies that have exceptional experience in areas such as pile driving for piers, among other services. However, the capabilities that they exhibit are primarily in the nearshore environment. While their capabilities are related to the work needed to be conducted offshore for the installation of jacket foundations, their capabilities would require a significant boost in scale to participate in these activities, which in turn would require major investment. This is not to say that the capabilities of these companies will not be viable in other areas of the offshore wind supply chain, each of these companies have listed themselves in other sub-sectors within the Construction, Installation and O&M Services sector such as Crane and Lift Operations and Marine Construction where their capabilities would translate well into what would be needed for the completion of an offshore wind project.

Figure 8-2 shows the changes that were experienced in relation to the companies listed within the sub-sectors of the Construction, Installation and O&M industry sector both before and after the survey was conducted by BW Research, along with the projected number of companies as an output of the survey.

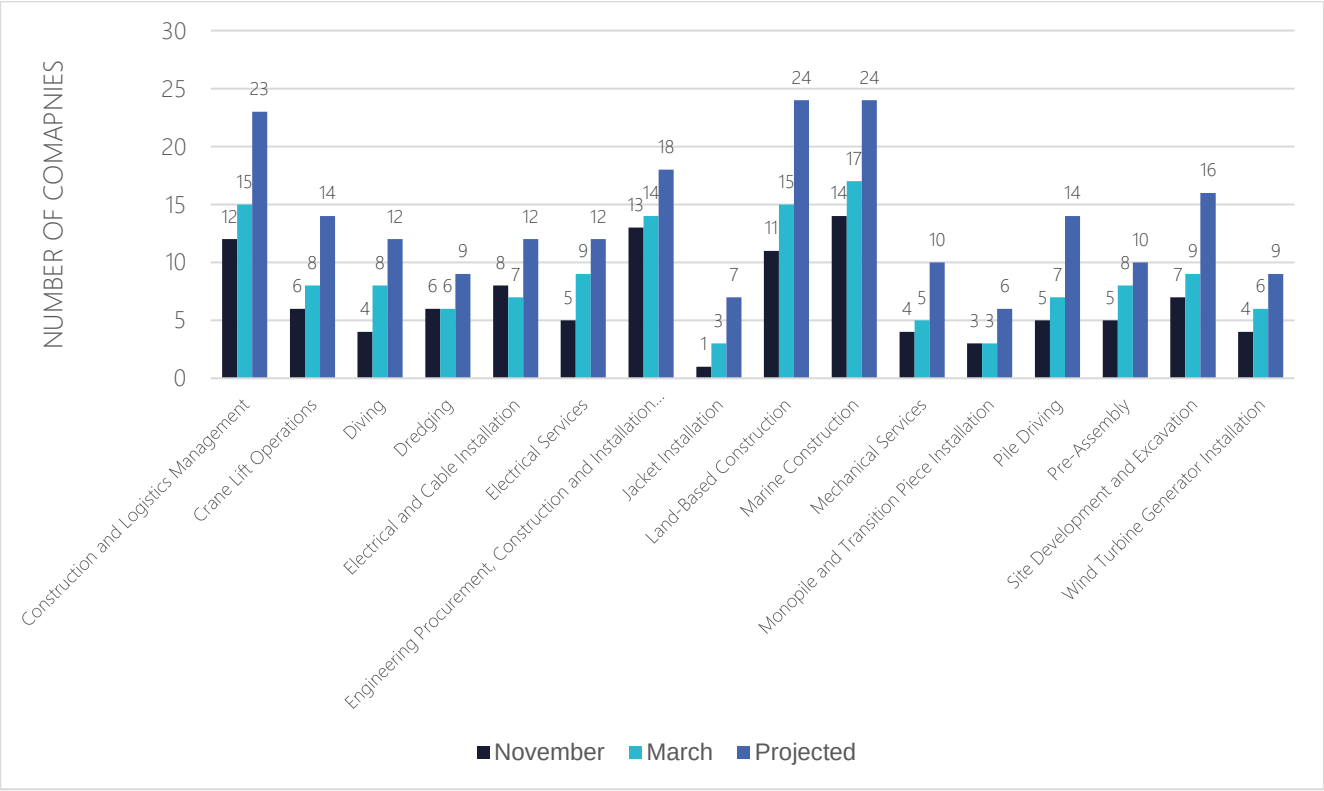


Figure 8-2 Construction, Installation, and Operation/Maintenance Services Breakdown

8.3 Manufacturing and Fabrication Services

The largest increase in the number of companies listed in the database, by percentage, was experienced in the Manufacturing and Fabrication Services Sector where the database experienced an increase of nearly 170% in the number of entries, or an additional 27 companies since November 2020. Large jumps in database entries were recorded in nearly all categories for the Manufacturing and Fabrication Services Sector indicating that outreach and marketing efforts in this area have successfully brought companies with a range of specializations into this part of the database. Many of the sub-sectors that had shown the most strength i.e (the greatest number of listings prior to administering the survey) still maintain a strong position, as shown in Figure 8-3. Companies capable of welding, machining, milling, etc. saw large increases, but it is also worth mentioning that some of the gaps where lower participation was seen in November, such as the case was for companies that administer coatings, saw increases on the order of 350%.

What isn't immediately clear is the relationship between volume and capacity of the companies identifying as providing manufacturing and fabrication services. This should be determined to fully understand the breadth and depth of the capability in this sector.

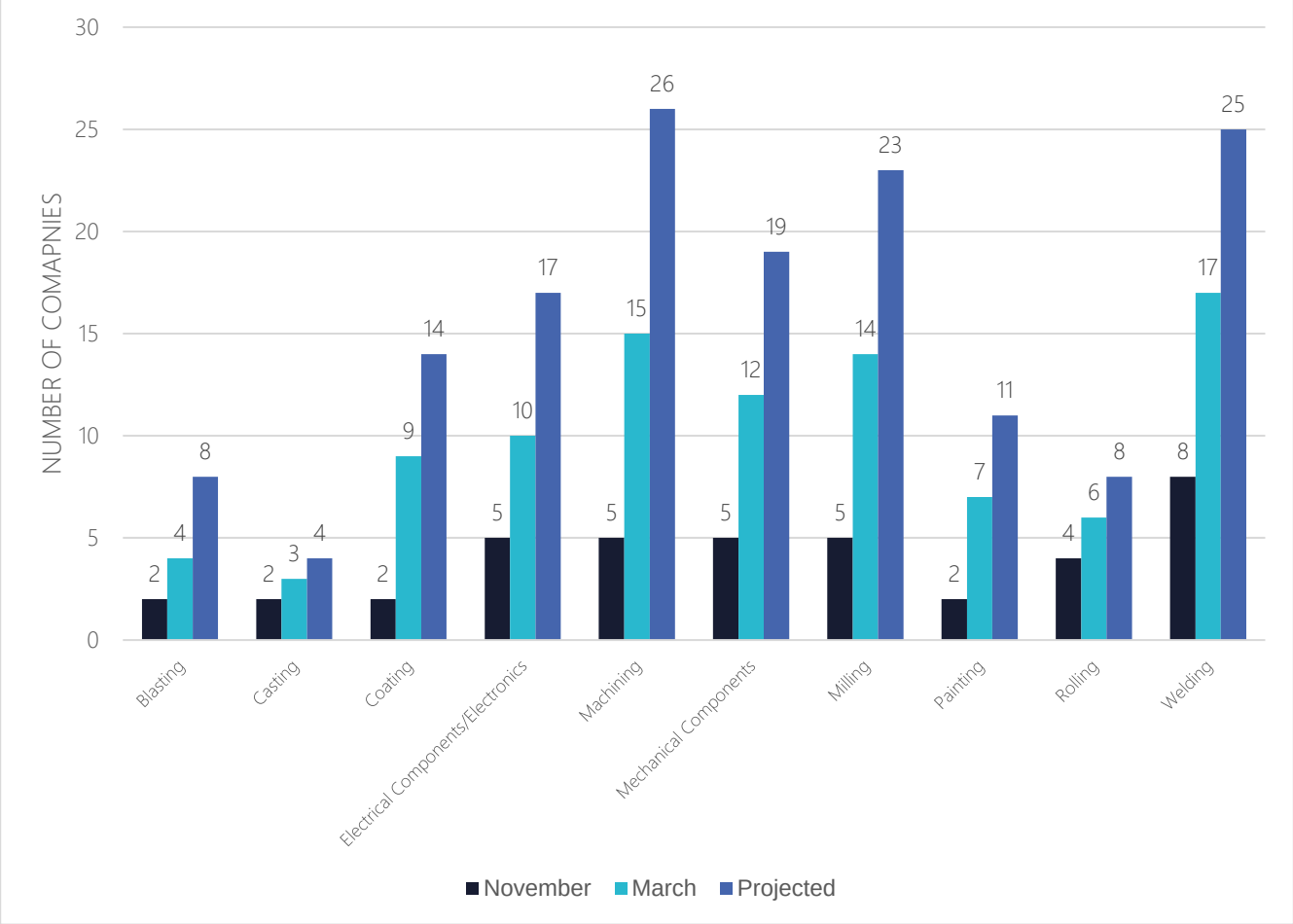


Figure 8-3 Manufacturing and Fabrication Services Breakdown

8.4 Original Equipment Manufacturing

The Original Equipment Manufacturer sector in the MassCEC database saw minimal growth from the time of the first interim report in November 2020 until March of 2021, this is visible in Figure 8-4. There was only one additional company that was added to the database in this sector that fell within the sub-sector of Transition Pieces. The new company that registered in the database was an OEM that utilizes 3D printing technology to create high-strength

equipment such as brackets, harnesses, sensor mounts and more. The company has worked specifically with Siemens Gamesa and have noted this relationship in their database entry. While this company will not be delivering full transition pieces for an offshore wind project, they may be creating smaller components such as brackets, sensor mounts and harnesses that will be included on the transition piece when it is completed. As a result of this, while the company is an aptly named OEM, it does not fit into the OEM categories present in the database, their capabilities fit into categories such as Mechanical Components under which they are also listed in the directory.

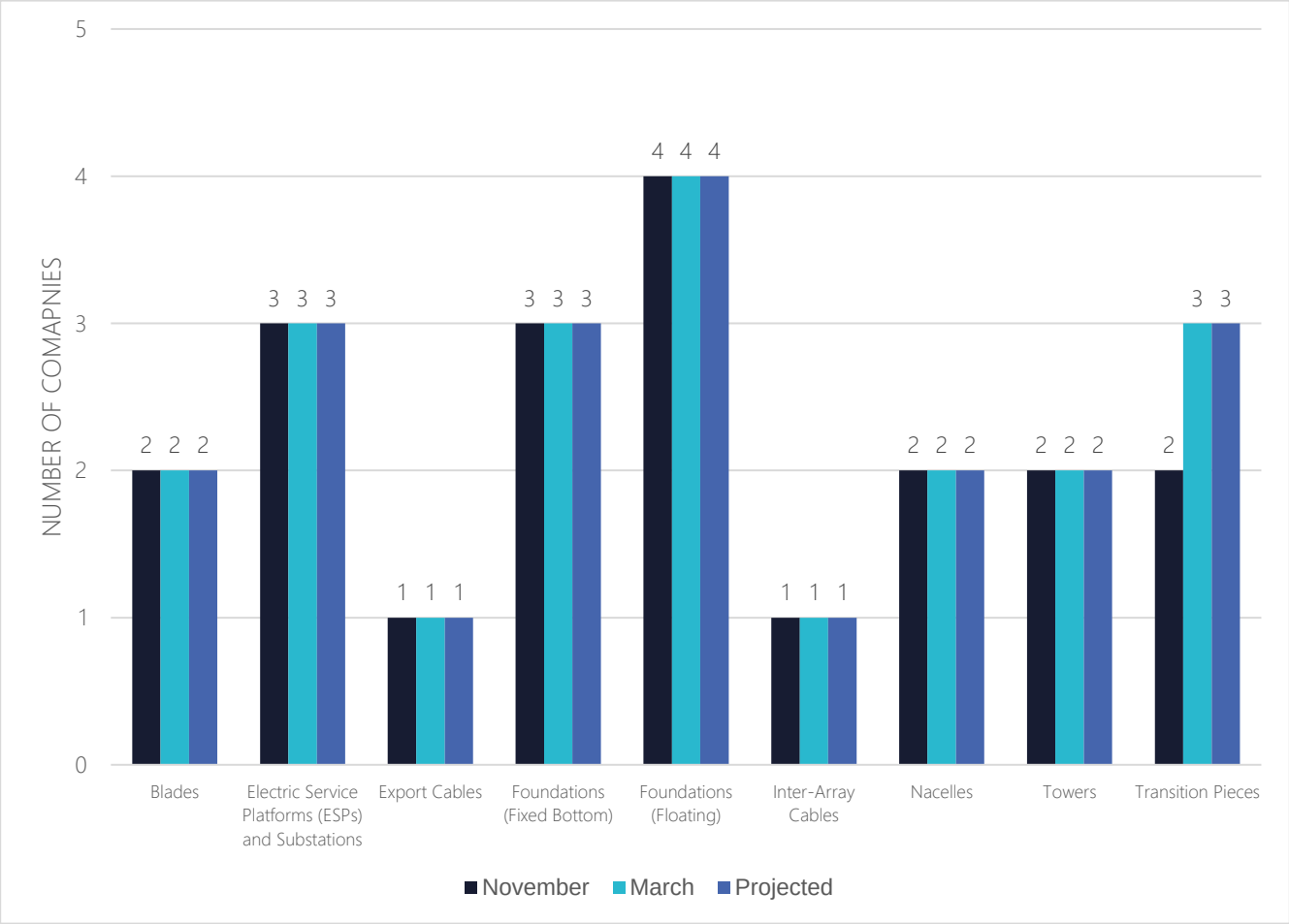


Figure 8-4 Original Equipment Manufacturing Breakdown

8.5 Marine Facilities, Transport, Logistics, and Safety

The Marine Facilities, Transport, Logistics and Safety sector of the MassCEC database saw an increase in a total of 13 companies, 7 of which indicated that they would be capable of providing Crew Transport Vessels. In total there are 15 companies as of March 2021 in the Crew Transfer Vessel sub-sector making it the strongest area within the Marine Facilities, Transport, Logistics and Safety sector by number of companies. Other increases were observed among critical sub-sectors such as Tugs / Barges / Towing and Marine Logistics; additionally, sub-sectors such as Fuel and Diesel, Vessel Inspection and Compliance, Pilots and more tallied their first companies partially filling some of the gaps that were identified in November. It is likely that there are more companies within these categories, most notably in the Fuel and Diesel sector that could provide critical services to vessels operating in the offshore wind industry in Massachusetts ports, however this was not reflected in the projected data that was generated from the respondents to the survey. There is certainly more than one fuel and diesel supplier in Massachusetts, but outreach from the survey did not capture their presence within the database, which is why Figure 8-5 shows a projected value of one in this sub-sector.

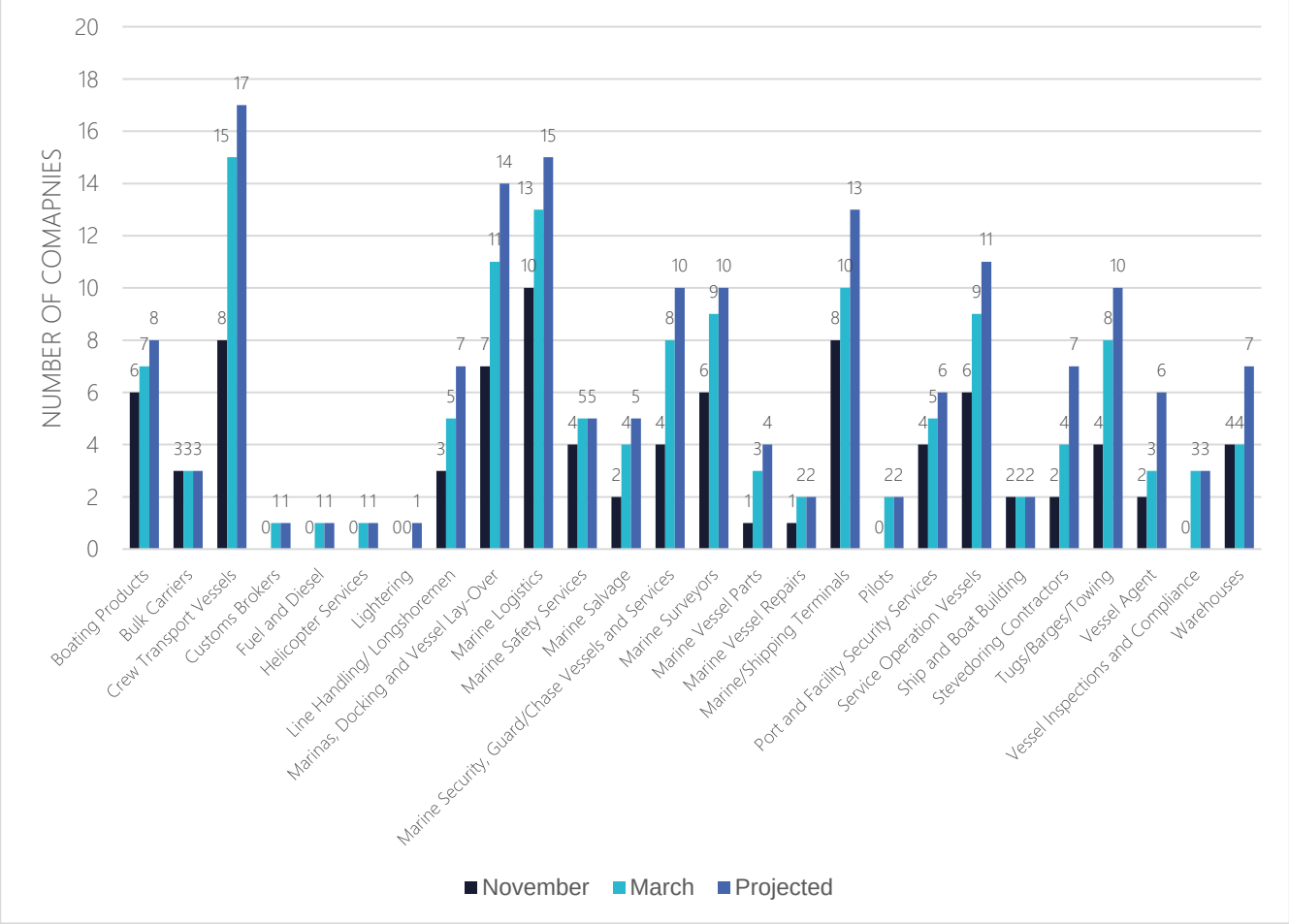


Figure 8-5 Marine Facilities, Transport, Logistics and Safety Breakdown

8.6 Equipment, Supplies, Materials, and Associated Services

The greatest increase in the total number of companies that registered for the MassCEC database between November of 2020 and March of 2021 came in the industry sector related to Equipment, Supplies, Materials and Associated Services. Overall, an additional 31 companies joined the database in this sector. The largest jump (+6) in entries occurred in the ROV, AUV and Subsea Equipment sub-sector; this sub-sector is a likely candidate for local content as the shipment of equipment from overseas to conduct subsea maintenance and surveys would likely not compete with local companies that are qualified in this area. Other sub-sectors including the Steel Plate, Pipe or Bar and the

Fasteners sub-sectors tallied their first companies in MA in comparison to the state of the database in November as is shown in Figure 8-6. These two sub-sectors are critically important in the delivery of an offshore wind farm so their presence in the database indicates that some gaps in the supply chain that were perceived in November were bolstered as of March 2021. It is also encouraging to see, at least regarding the supply of fasteners, that the projected number of companies in this area is greater than what is currently shown in the database.

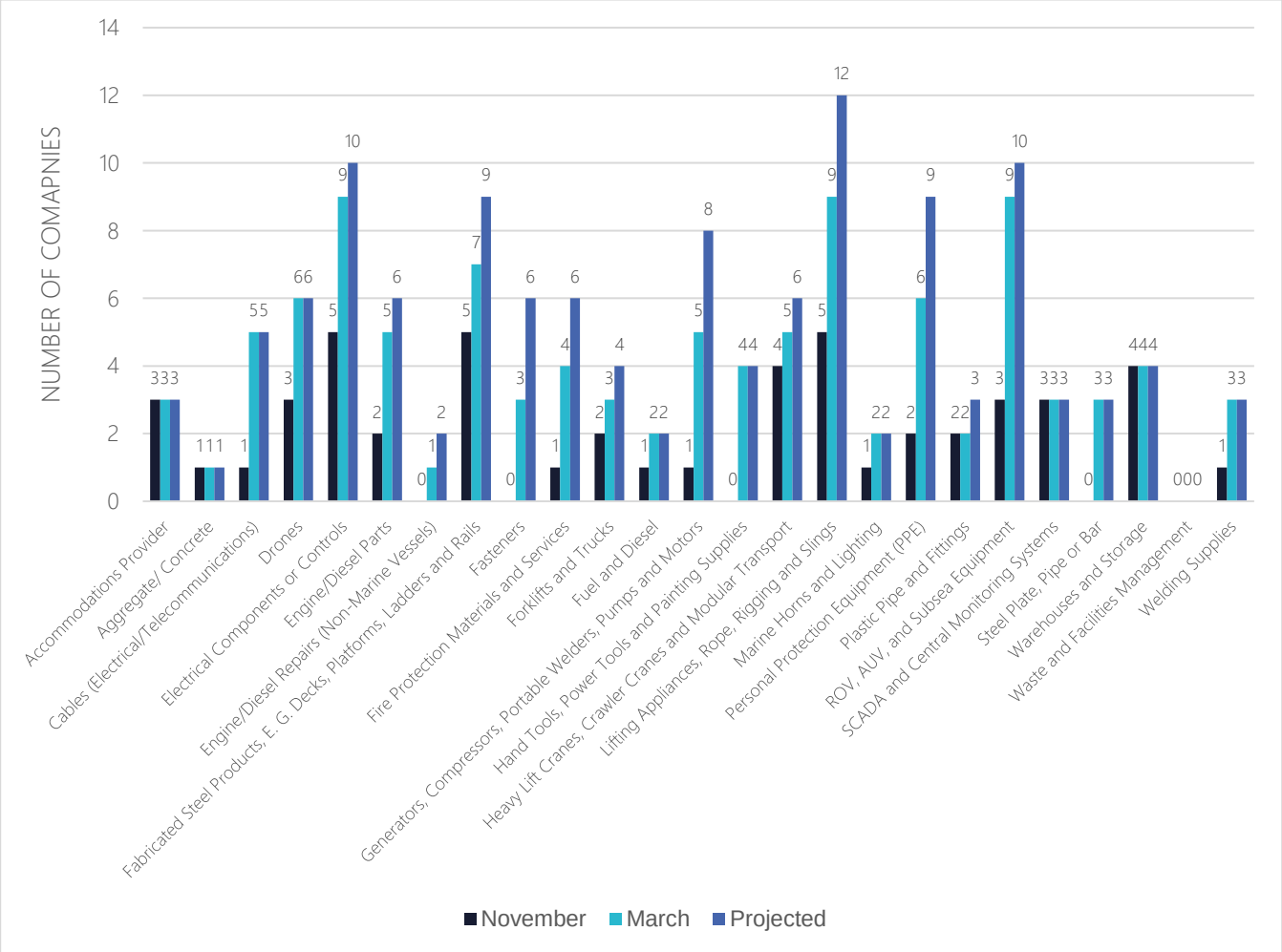


Figure 8-6 Equipment, Supplies, Materials and Associated Services Breakdown

8.7 Environmental, Engineering, Geological and Testing Services

The Environmental, Engineering, Geological and Testing Services sector is one of the major strengths of the offshore wind supply chain in Massachusetts. In phase one of this project, where interviews were conducted with various Tier 1 suppliers for the industry, many Tier 1's indicated specifically that these services were one of the main strengths of Massachusetts. It is shown in Figure 8-7 that there is a broad distribution of companies that are present within the many sub-sectors of this portion of the industry. Since November of 2020, there has been a relatively evenly distributed increase in the number of companies in each of the sub-sectors, in total, there were an additional 14 companies that registered between November and March of 2021. From these new additions to the database each subsector grew by an average of 4 companies. This trend goes to show that the strength in this area of the supply chain that was observed in Phase 1 of this project is apparent in this phase (Phase 3) as well.

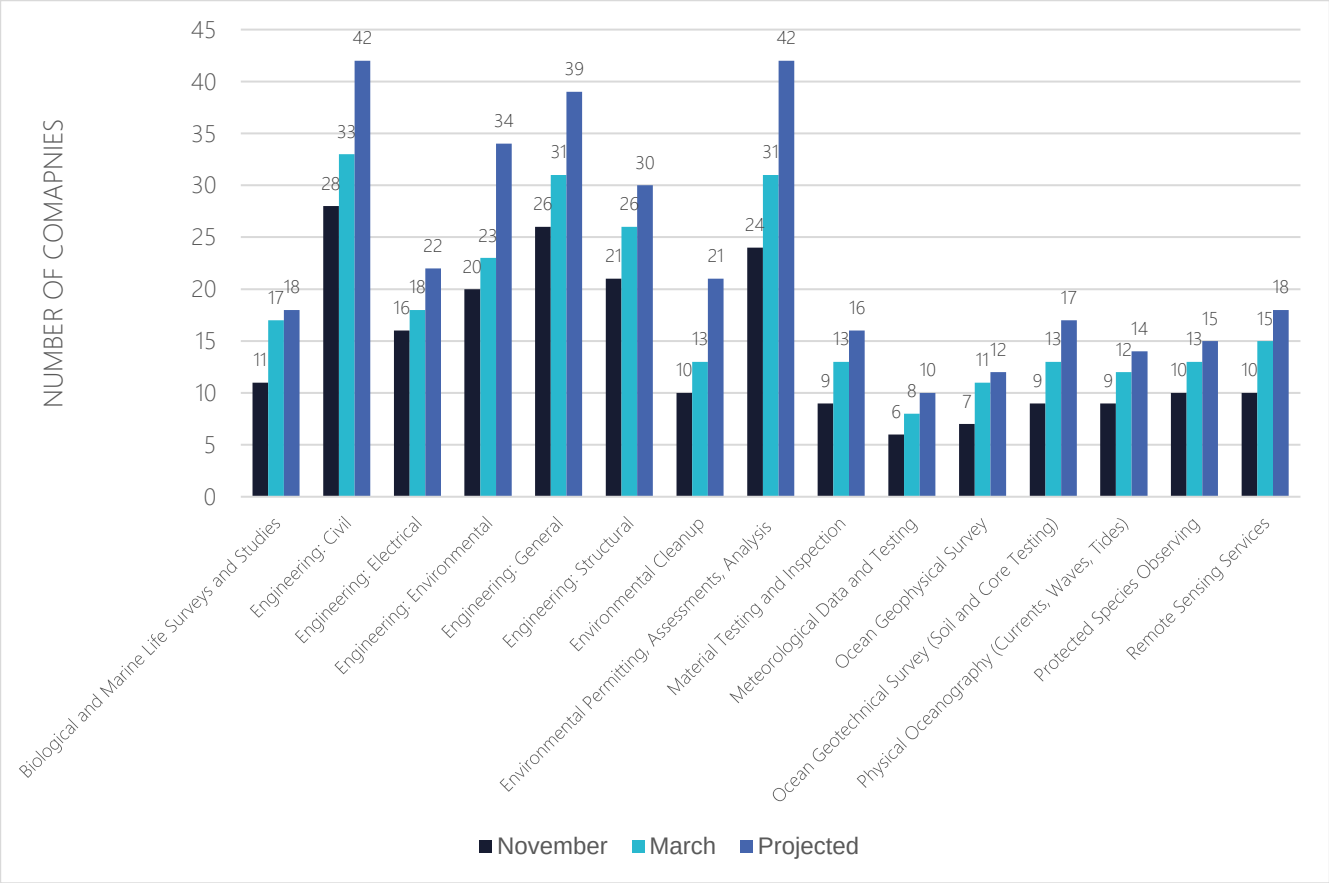


Figure 8-7 Environmental, Engineering, Geological and Testing Services Breakdown

8.8 Professional and Consulting Services

Many of the consulting roles that are related to more technical disciplines have a strong presence within the Professional and Consulting Services sector of the MassCEC database. For instance, services related to Geographic Information Systems (GIS), Energy Market Analyses and consulting companies with competency in the transmission and interconnection space all had over 10 companies listed in the database in November of 2020 and nearly every sub-sector saw a growth in the number of companies by March of 2021. While the strength of these more technical consulting disciplines is great, there are very few companies within the database that showed capabilities in areas related to financial and legal services as is shown in Figure 8-8. In areas related to these disciplines such as Financial Statement Preparation, Tax Accounting Services, Payroll Processing, Business / Corporate Law, Mergers and Acquisitions Law, among other sub-sectors, there was very little representation within the database both prior to the BW survey in November 2020 and after it in March of 2021. While the MassCEC database has strong ties to companies with technical backgrounds, engaging with companies and firms well versed in the legal and financial side of things would bolster this area of the supply chain when looking at the database. It is important to note that there were several respondents to the survey from companies / agencies in this sector, however none of them specified the sub-sectors of which they belonged to. Due to this fact, the projected values of each sub-sector were maintained at a level equal to what the database was reflecting in March of 2021.

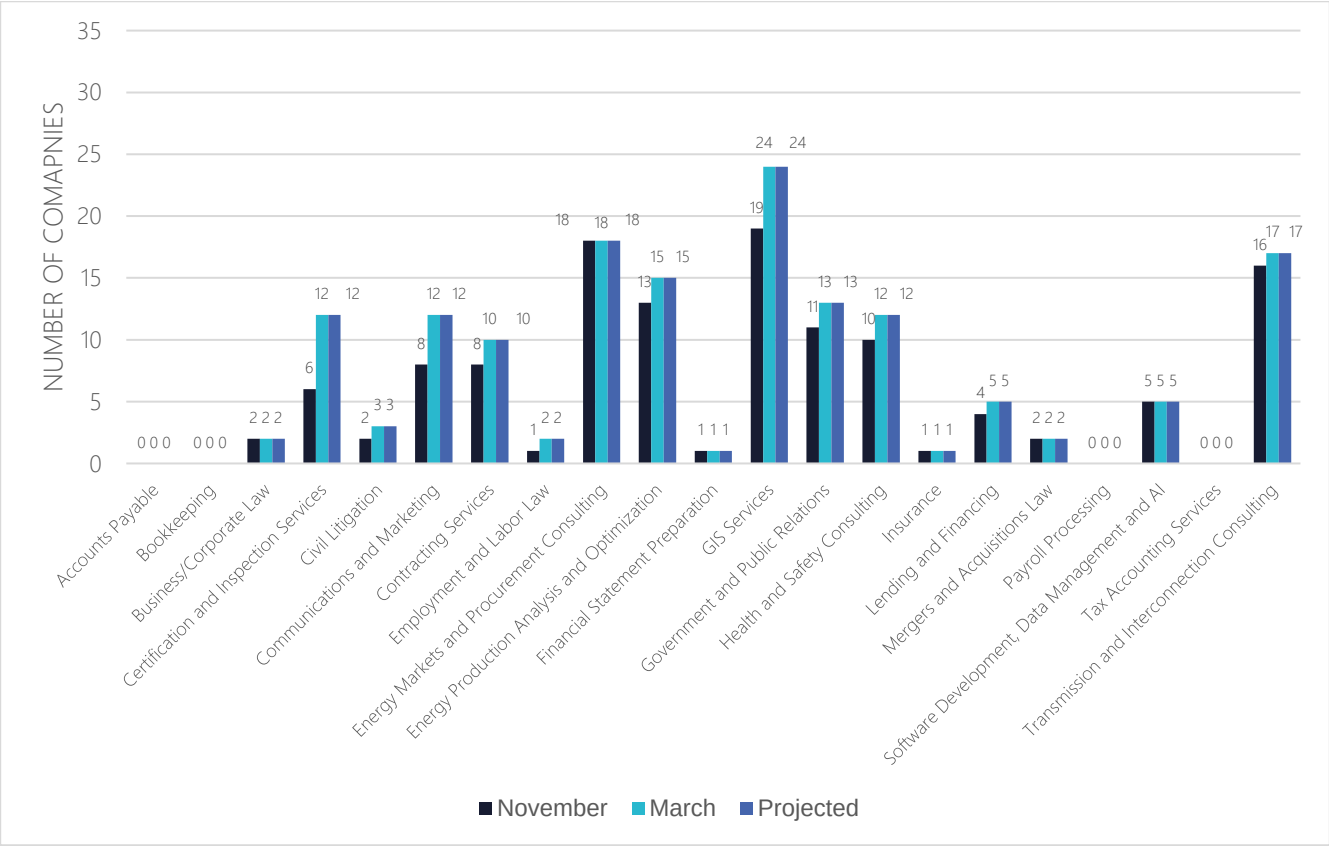


Figure 8-8 Professional and Consulting Services Breakdown

8.9 Offshore Wind Developers

There was a very small amount of growth in the Offshore Wind Developers sector of the MassCEC database. As one can see in Figure 8-9 only two companies were added to the ranks of the Project Developer sub-sector under which major companies such as Vineyard Wind and Equinor were present in November of 2020. The two additional companies that registered under this sub-sector are not traditional offshore wind developers such as Vineyard Wind and Equinor, as they do not own a stake in any lease areas anywhere in the world. It is also important to note that the specializations that the new companies exhibit are more closely tied to ecology, oceanography and engineering. The inclusion of the language (Offtake, Permitting, Construction) within the title of this sub-sector likely attracted these companies as each of them could assist in either permitting or some form of construction, but not in the traditional Project Developer sense, such as how Vineyard Wind and Equinor develop offshore wind projects in all three of these areas.

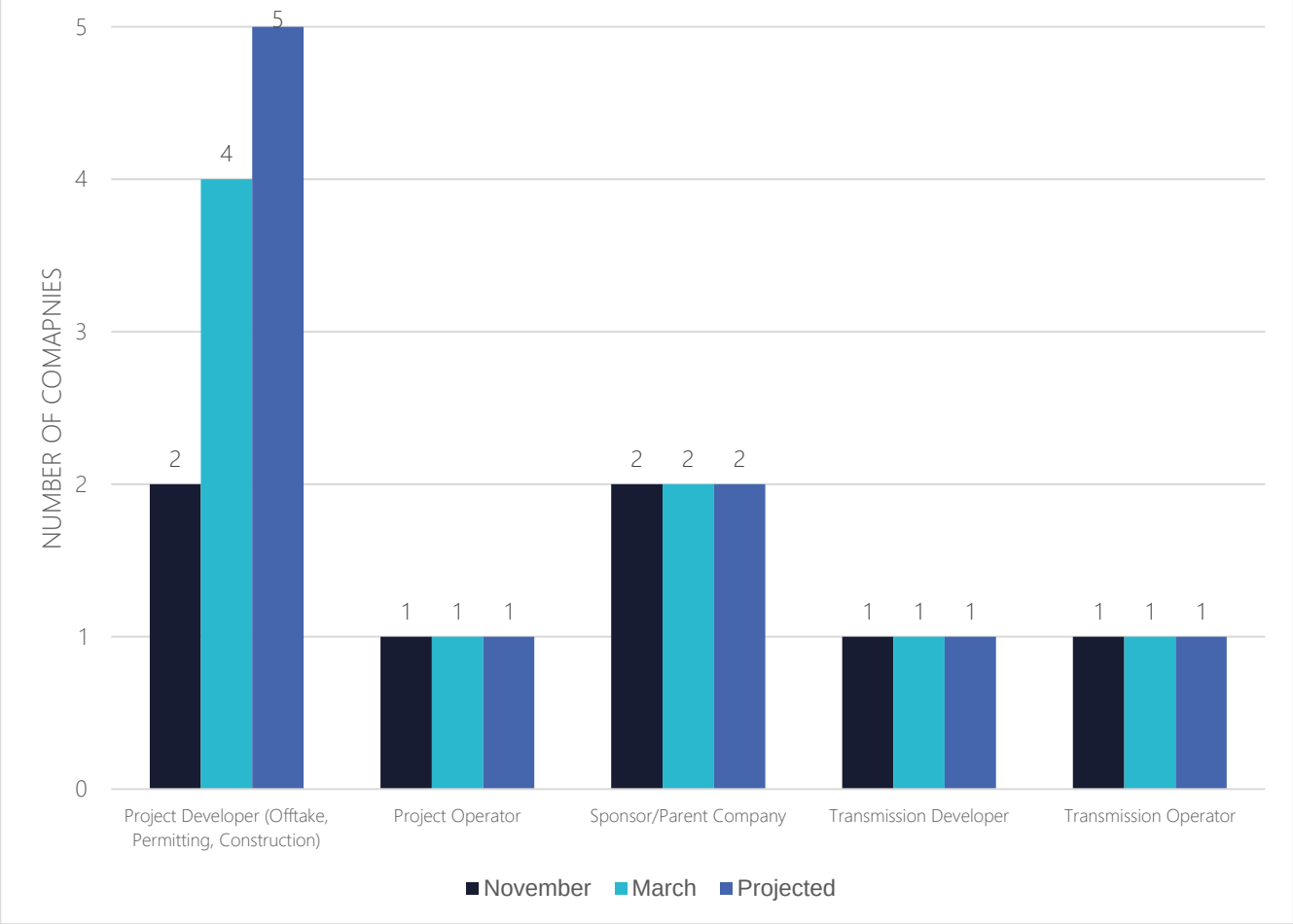


Figure 8-9 Offshore Wind Developers Breakdown

8.10 Educational Institution / Training Provider

Only a total of 6 additional companies / educational institutions registered in the MassCEC database while the survey by BW Research was conducted and completed. One of these educational institutions was the Greater New Bedford Regional Vocational Technical High School, which fell within the sub-sectors of Vocational High School as well as Workforce and Skilled Trades Training. Other institutions and companies such as the MassMEP and ExoLytic, Inc. are training providers that helped bolster the strength of the database surrounding Health, Safety and Environmental training. This industry sector is rather unique in that many of the other industry sectors focus on improving the network of companies within the supply chain, however this industry sector looks to improve the workforce so that capable and qualified individuals will be able to take part in the growing offshore wind industry in the US. The more training and

education opportunities that are offered in Massachusetts the more adept the workforce will be when construction begins on many of the offshore wind projects off Massachusetts' coast. Figure 8-10 illustrates the increases in the number of companies / educational institutions by their respective capabilities in each sub-sector, alongside the projected values generated as a result of the BW Survey.

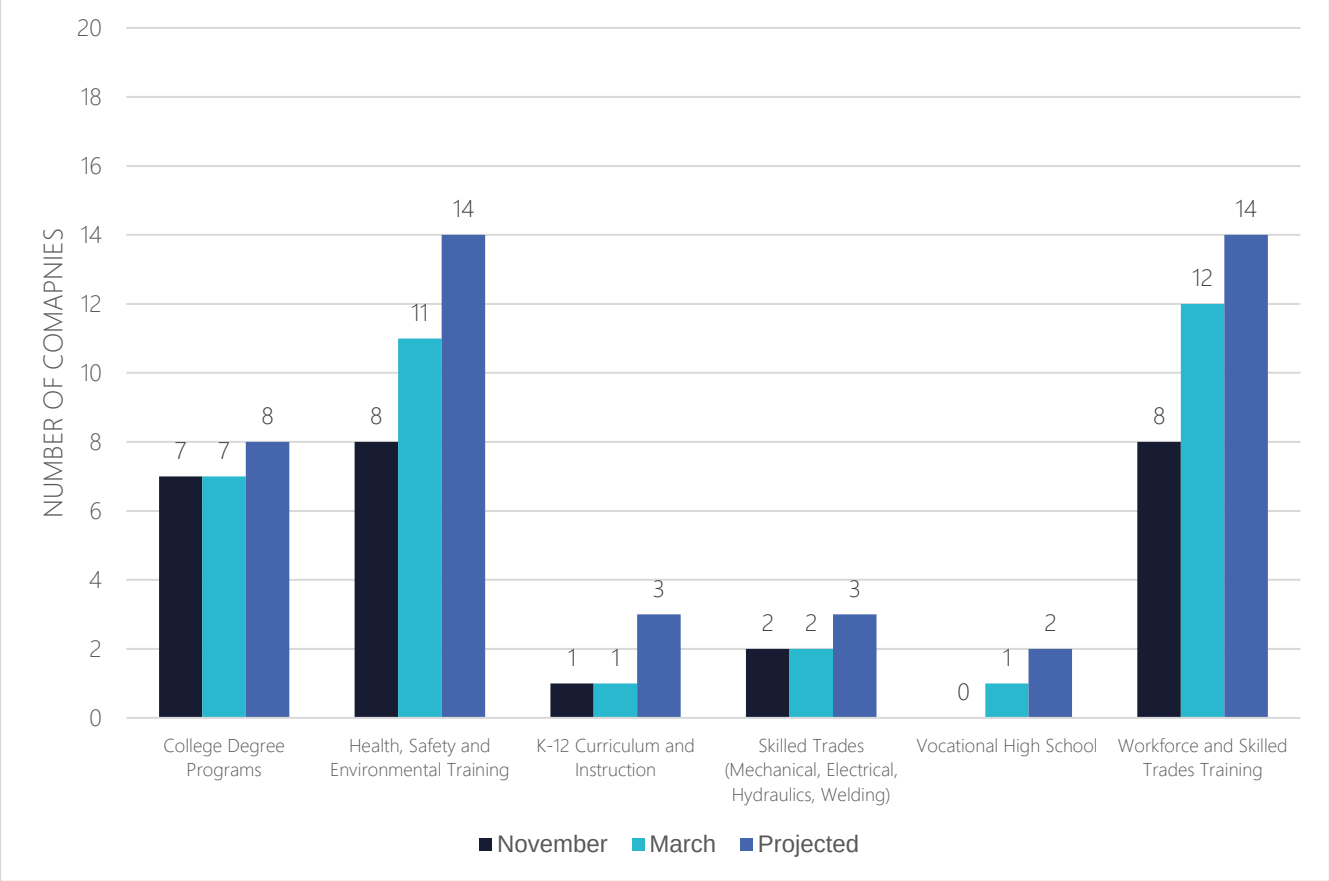


Figure 8-10 Educational Institution / Training Provider Breakdown

8.11 Government Agencies

There are many parallels that can be drawn between the Government Agencies sector of the MassCEC database and the Educational Institution / Training Provider Sector. While the Government Agencies sector also has a sub-sector related to Workforce Development, there are many other sub-sectors that apply to the regulatory hurdles that must be cleared prior to constructing and operating an offshore wind project. Half of the sub-sectors within the Government Agencies branch of the database saw no change in the number of companies that were listed, however areas involving Economic Incentive Programs, Environmental Review and Permitting and Programmatic Support for Offshore Wind

increased nominally. The increases that were experienced in each industry sector are represented in Figure 8-11. It is important to note that there were several respondents to the survey from companies / agencies in this sector, however none of them specified the sub-sectors of which they belonged to. Due to this fact, the projected values of each sub-sector were maintained at a level equal to what the database was reflecting in March of 2021.

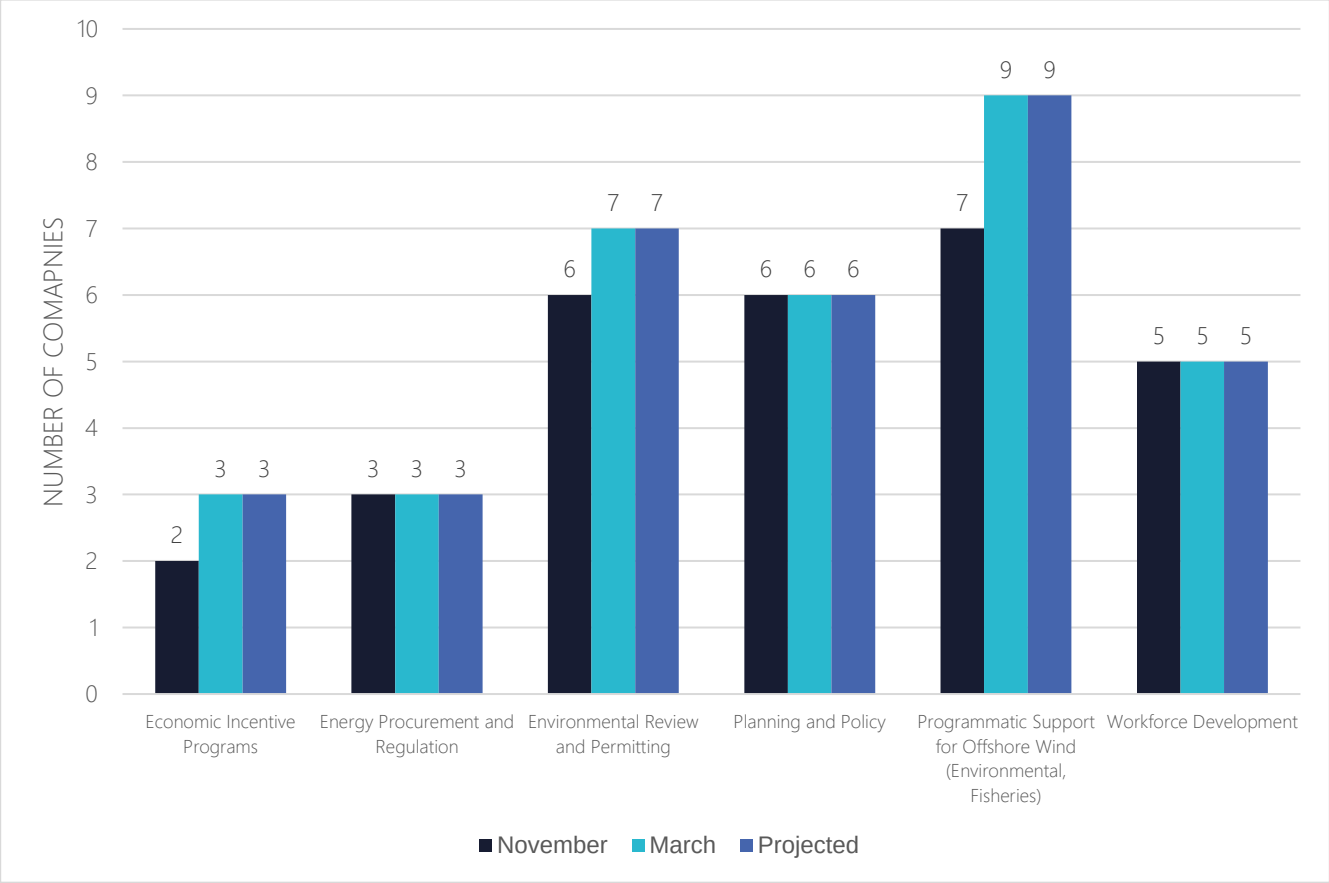


Figure 8-11 Government Agencies Breakdown

8.12 Trades, Labor and Workforce Organizations

The final industry sector involving Trades, Labor and Workforce Organizations saw an increase of four additional companies to its ranks. In this sector Non-Government Organizations logged their first two participants within the database, and the predicted level of growth in the Trade / Industry Association and Workforce Provider sub-sectors, illustrated in Figure 8-12 indicates that the strength in these areas is greater than it currently appears within the database.

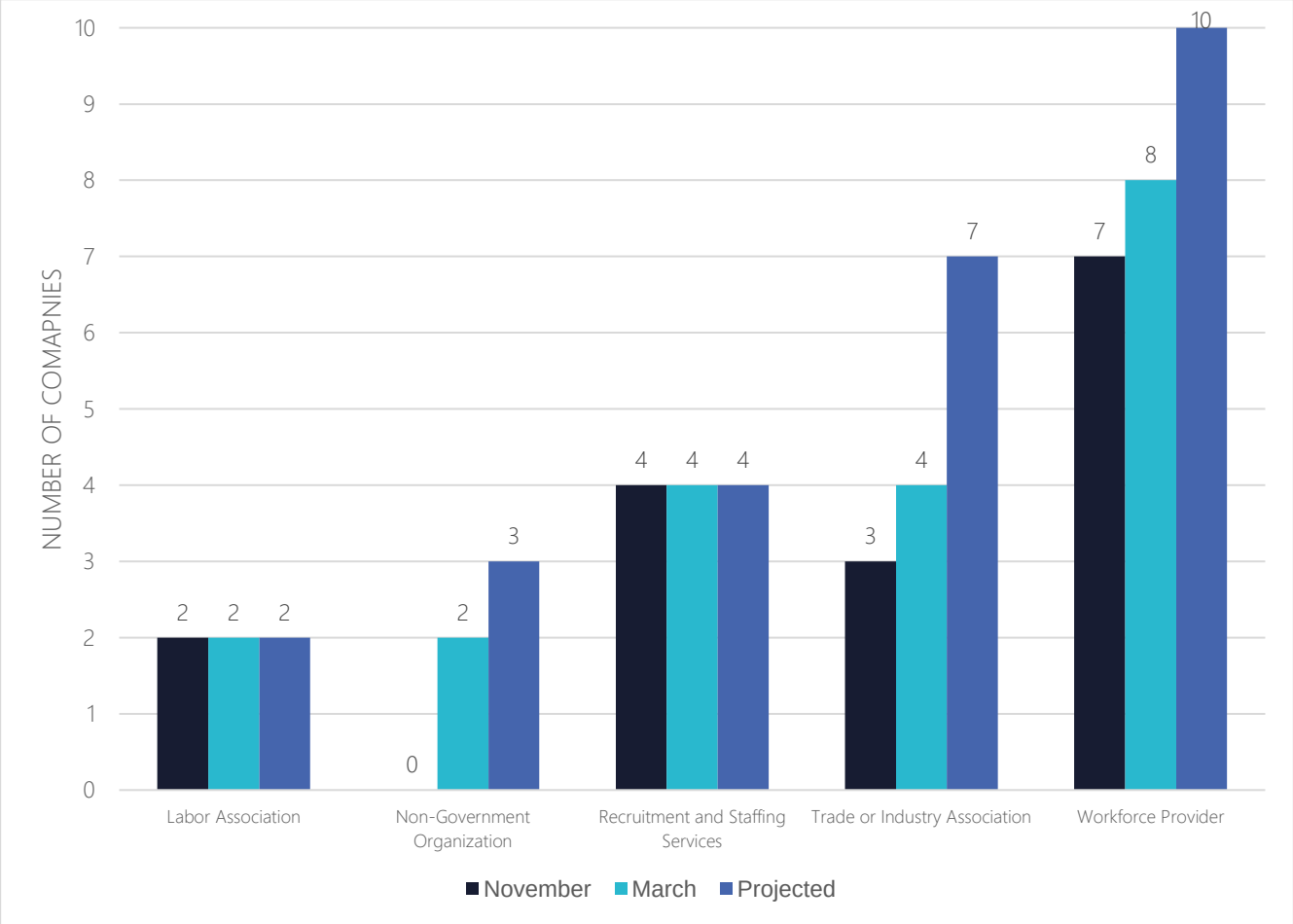


Figure 8-12 Trades, Labor and Workforce Organizations Breakdown

9 TASK C - MASSACHUSETTS SUPPLY CHAIN OPPORTUNITY ANALYSIS

9.1 Project Development

The project development category includes the services contracted prior to the developer reaching final investment decision (FID). This includes surveys and studies required to inform wind farm project and component design, as well as to obtain necessary construction permits.

52.4% of firms identified by BW are operating in the project development phase of the project.

9.1.1 Development & Permitting

Assessment

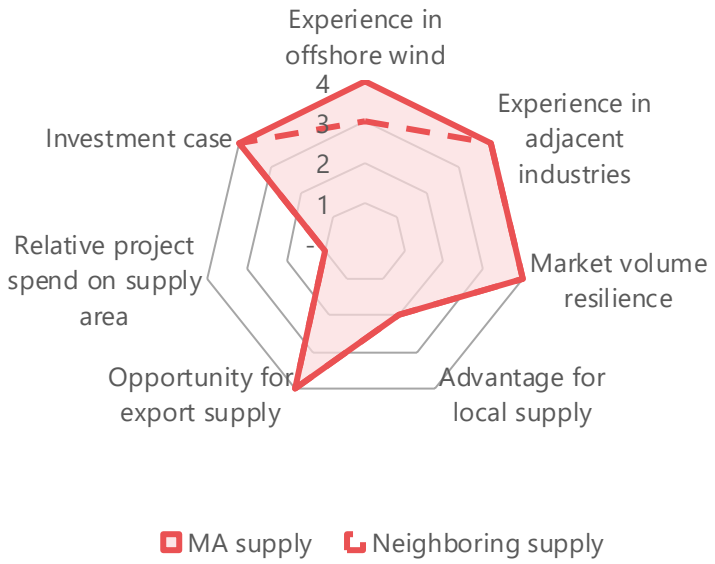


Figure 9-1 Assessment of MA and neighboring state development and permitting opportunity

- Experience in offshore wind – A number of MA based firms have supported projects development from assisting with Site Assessment Plans (SAPs) and Construction and Operations Plans (COPs) through to owners engineering and permitting advisory. Most COPs submitted to the Bureau of Ocean Energy Management (BOEM) have been submitted by firms who are headquartered or have a presence in MA.

- Experience in adjacent industries – The capability to support offshore wind developers in the development phase of the project comes from a deep-rooted experience in supporting large civil infrastructure and energy infrastructure projects onshore, such as in onshore wind, solar and natural gas.
- Market volume resilience – The companies supporting development and permitting of offshore wind projects were largely established prior to the emergence of the US offshore wind industry and will support industries beyond offshore wind, although permitting for offshore infrastructure is not commonplace.
- Advantage for local supply – These services can be delivered from multiple locations with the only advantage of delivering locally being the ability to engage with local stakeholders, state authorities and non-governmental organizations (NGOs). Local firms may have some advantage due to their track record in supporting project development and permitting.
- Opportunity for export supply – Support for project development and permitting can be provided by non-local suppliers with negligible logistical barriers. Where states have inexperienced local supply chain to support project permitting MA companies with experience have good opportunity to supply.
- Relative project spend on supply area – This portion of the project phase spend typically accounts for less than 1% of total project costs.
- Investment case – Companies in MA are already fully capable of providing support so no additional investment to supply is necessary.

Discussion

Development and permitting emerges as an area of strength for the MA supply chain, with around 40 companies represented in the MassCEC supply chain database with capability to support some aspect of wind farm development. With lease areas supporting multiple phased developments MA firms are well placed to capture this further permitting work for future phases both locally to the MA lease area but also along the east coast due to established relationships with offshore wind developers and a growing track record, combined with lessons learnt, in the US offshore wind permitting process.

Companies with presence in MA who have already supported project development and permitting for US offshore wind projects include Jacobs, Normandeau Associates, Ramboll, Tetra Tech, VHB and Woods Hole Group. CSA Ocean Services and Gray and Pape, both in Rhode Island, have also supplied in this area.

9.1.2 Surveys

Assessment

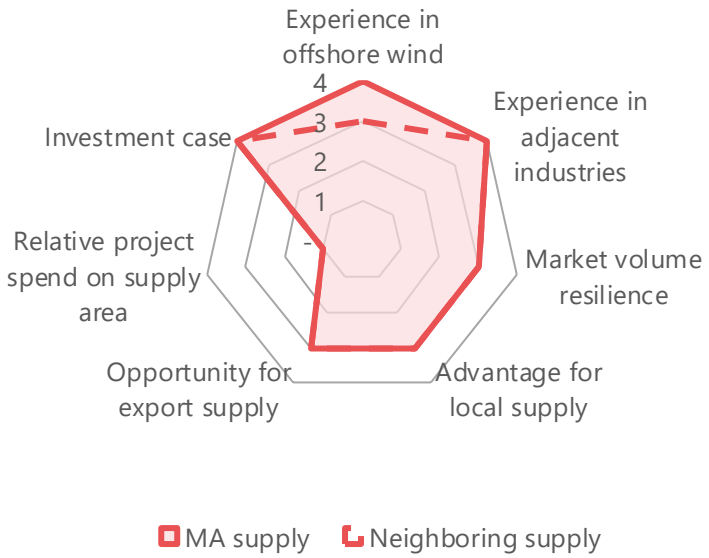


Figure 9-2 Assessment of MA and neighboring state surveys opportunity

- Experience in offshore wind – Multiple MA based companies have provided a variety of survey services for offshore wind projects including geotechnical, geophysical, environmental and metocean surveys. Boston Harbor Cruises MV Commander carried out geotechnical survey work at Ocean Wind for Ørsted in 2019, and CR Environmental performed geological surveys for Vineyard Wind.
- Experience in adjacent industries – Surveying capability has been transferred from adjacent industries where MA has strengths, in particular onshore terrestrial environment surveys.
- Market volume resilience – Surveying is required in other industries but offshore wind presents significant opportunity for offshore surveying services.
- Advantage for local supply – Local understanding of the environment and marine logistics can be a key differentiator for survey services. Local vessels are often used to undertake environmental surveys. MA has a strong marine and ocean R&D capability that is well positioned to take advantage of this.
- Opportunity for export supply – The logic of export supply is strong for the main site investigation work, as this is further offshore and less reliant on local knowledge of the environment. Onshore and nearshore site investigation and environmental surveys benefit from local expertise and understanding and therefore there will be limited opportunity for exporting these services if there are capable local suppliers in competition.

- Relative project spend on supply area – This portion of the project phase spend typically accounts for less than 1% of total project costs.
- Investment case – MA firms operating in the survey (onshore or offshore) market will need to make minimal investment to be able to support the offshore wind industry. The industry has seen large mutli-national survey companies such as Fugro and MMT enter the US offshore wind market in the very early stages and dominate the large site investigation scopes. Where local survey firms will see success is in smaller nearshore and environmental focused scopes.

Discussion

Surveying has also emerged as a potentially strong area of capability for the MA supply chain. With lease areas supporting multiple phased developments MA firms are well placed to capture further survey work for future phases. MA survey firms should leverage their local knowledge to provide specialist survey pertaining to local environmental sensitives, such a as biological sciences, onshore surveys and nearshore geophysical and geotechnical surveys.

Companies with presence in MA such as Boston Harbor Cruises, Cathie, CR Environmental, Fathom Research, GEI Consultants, Steele Associates, and Woods Hole Group have capability to support surveys for offshore wind. CSA Ocean Sciences, Inspire Environmental (both Rhode Island), Ocean Surveys and ThayerMahan (both Connecticut) may provide this capability from neighboring states.

As seen with the permitting delays with Vineyard Wind the requirement to have an understanding of the cumulative impacts of multiple wind farms on the environment and how they could significantly lower the risk of project development represent a significant opportunity out with the traditional 'required' offshore wind surveys. It is anticipated there will be multiple opportunities to provide survey support for federal and state agencies in this regard as they seek to gather supporting data to fully establish a baseline for cumulative impacts.

9.1.3 Engineering & Design

Assessment

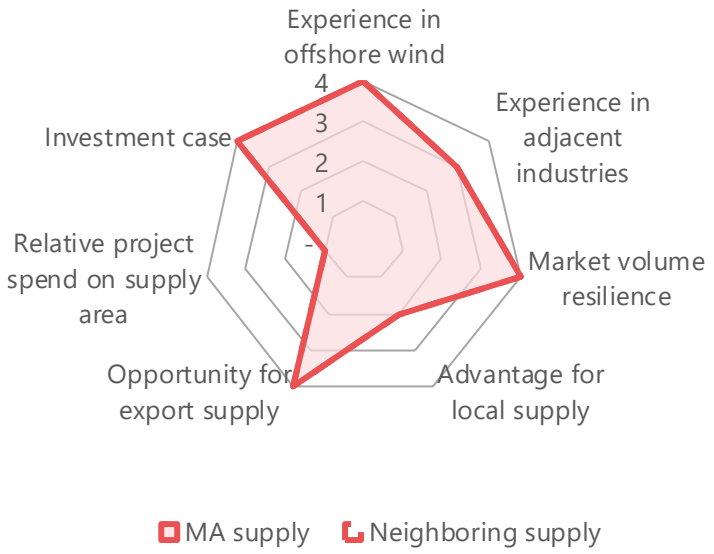


Figure 9-3 Assessment of MA and neighboring state engineering and design opportunity

- Experience in offshore wind – Multiple MA based companies have provided a variety of engineering and design services for projects such as Block Island, Vineyard Wind, Empire Wind and Mayflower Wind.
- Experience in adjacent industries – The capability to support offshore wind developers in the development phase of the project comes from a deep-rooted experience in supporting large civil infrastructure and energy projects, such as onshore wind, solar and oil and gas. New entrants from adjacent industries will need to understand specific requirements of wind farm and component design.
- Market volume resilience – The companies supporting the offshore wind industry were largely established prior to the emergence of the US offshore wind industry and suppliers can support industries beyond offshore wind.
- Advantage for local supply – Competitive advantage is not defined by supplier location but several MA based companies have capability to offer services.
- Opportunity for export supply – As there is no strong logistics benefit to supply MA based companies will find opportunities to export services.
- Relative project spend on supply area – This portion of the project spend typically accounts for less than 1% of total project costs.

- Investment case – The expertise and equipment required for most project engineering and design services is used across several sectors.

Discussion

Engineering and design encompass several industry sectors where there are companies with a presence in MA, including offshore, civil, electrical, environmental, structural and general engineering. These subsectors combined make this the area with the high number of firms available to support the needs of the offshore wind industry. It is projected that there are the following number of companies in the engineering sector:

- 42 civil engineering firms;
- 22 electrical engineering firms;
- 34 environmental engineering firms;
- 39 general engineering firms and;
- 30 structural engineering firms.

(Note individual firms are represented across all multiple engineering sub-sectors where they have capability).

With lease areas supporting multiple phased developments MA firms are well placed to capture this further engineering and design work for future phases, both locally to MA lease areas but also to offshore wind projects along the east coast, due to established relationships with offshore wind developers and growing track record.

Companies with presence in MA and track record in supporting engineering and design of US offshore wind projects such as Cathie, DNV, EN Engineering, Jacobs, Ramboll, Ventolines, VHB, WSP, and Xodus Group, show that MA is well placed to be a central hub for professional services.

9.1.4 Project Management

Assessment

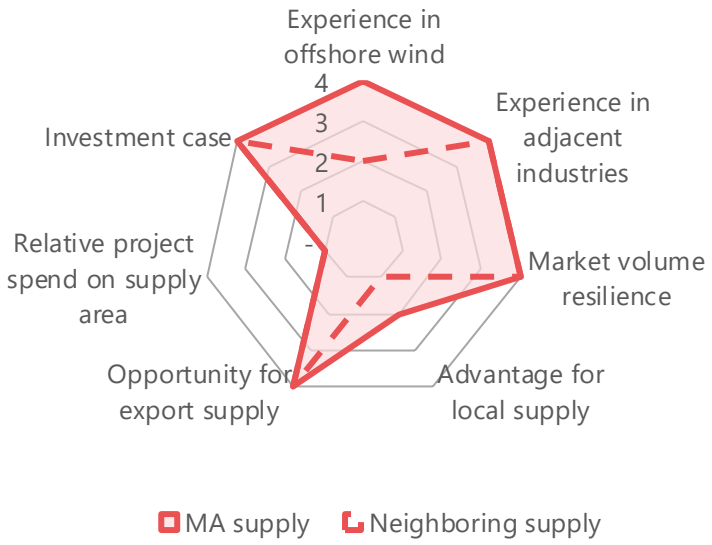


Figure 9-4 Assessment of MA and neighboring state project management opportunity

- Experience in offshore wind – The majority of offshore wind project management is undertaken by the project developer. Multiple MA based companies have provided a variety of project management services, including insurance, legal and owners engineering, for projects such as Block Island, Vineyard Wind, and CVOW.
- Experience in adjacent industries – Provision of project management services can come from companies in adjacent industries with an understanding of offshore wind.
- Market volume resilience – Companies providing project management services are largely established independent of offshore wind opportunity and have capability to support a wide range of other sectors.
- Advantage for local supply – Most project management services can be delivered independent of location. Competitive advantage is based on capability and track record.
- Opportunity for export supply – MA based suppliers of project management services will be able to access multiple US projects.
- Relative project spend on supply area – This portion of the project spend typically accounts for less than 1% of total project costs.
- Investment case – Project management support services are often ubiquitous and can be applied to support other sectors. No additional investment required to support the offshore wind sector.

Discussions

Early US offshore wind projects being created by project developers that are new to the sector with limited offshore wind experience in-house may create increased opportunity for some project management support services, though in time more of this requirement is likely to be undertaken by internal project development teams. External support services will still be required in areas such as financial, legal, insurance, recruitment and software where MA firms with project knowledge and track record will be able to supply.

Companies with a presence in MA that have provided project management support services to US offshore wind projects include EN Engineering (as Energy Initiatives Group), ERSG Global, Lautec, Marsh USA, Offshore Construction Associates, Pierce Atwood and Ventolines.

9.2 Wind Turbine Supply

The wind turbine supply category includes general components of the WTG supply contract. The assembly of the WTG is carried out by the WTG OEM with the elements of the rotor, nacelle, and tower; broad terms for several Tier 2 and below supply packages.

9.2.1 Rotor

Assessment

Figure 9-5 Assessment of MA and neighboring state turbine rotor supply opportunity

- Experience in offshore wind - Major turbine OEMs have presence in MA however none have established a blade fabrication facility to date. TPI Composites have turbine blade tooling technology centre in Rhode Island but no manufacturing facility for offshore turbine blades.
- Experience in adjacent industries – While specific opportunities do exist, particularly further down the supply chain (Tier 2 or 3), they face several challenges in terms of competing with experienced and established supply chains to the Tier 1s. The opportunity for companies in adjacent industries will likely depend on the location of US blade fabrication facilities.
- Market volume resilience – The same skills and tools (though at different scale) are also required in onshore wind.
- Advantage for local supply – Local supply of blades could reduce logistical challenges associated with marshalling.

- Opportunity for export supply – Blade manufacturers typically have a single blade facility to serve the whole nearby geographical market. Given the volume of projects in the north east there should be an appetite for a facility to be located in MA with the ability to export to the entire US industry.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 4% of total project costs.
- Investment case – A high level of investment would be required to establish a blade facility in MA but the long-term US project forecast supports the investment case if a suitable location can be found. Although the investment case is unlikely to require public sector support, multiple states may be looking to incentivize manufactures due to the economic benefits a local fabrication facility would enable.

Discussion

If MA could attract a major OEM blade manufacturing facility, this could support growth of a secondary supply chain. Incentives could be used to attract the manufacturer as the investment is large and by showing a willingness to co-invest in success MA would demonstrate further commitment to the offshore wind industry. The goal would be to form a cluster and both Tier 1s and developers would fully support such an effort. Suitably located land adjacent to a port is at a premium and would likely require significant refurbishments and modifications.

MA has already established itself as a US leader in turbine blade testing through the presence of the testing facility in the Port of Boston. Access to state-of-the-art testing facilities should be leveraged in attracting a blade manufacturing facility to locate nearby.

Figure 9-6 MassCEC Wind Technology Testing Center

9.2.2 Nacelle

Assessment

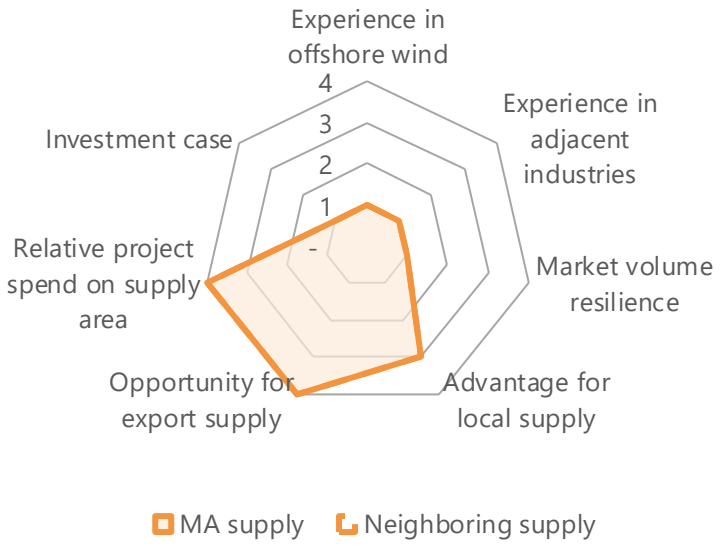


Figure 9-7 Assessment of MA and neighboring state turbine nacelle supply opportunity

- Experience in offshore wind – The three major offshore wind turbine OEMs have presence in MA, however none have established a local nacelle assembly facility to date.
- Experience in adjacent industries – While specific opportunities may exist, particularly further down the supply chain (Tier 2 or 3), they face a number of challenges in terms of competing with experienced and established supply chains to the Tier 1s.
- Market volume resilience – A US nacelle assembly facility will be entirely dependent on the size of the offshore wind market.
- Advantage for local supply – Local supply of nacelles would reduce logistical challenges associated with marshalling.
- Opportunity for export supply – A nacelle assembly facility would serve the whole geographical market. Given the volume of projects in the US pipeline there could be appetite form the turbine OEMs to eventually establish US nacelle assembly facilities, which could be located in MA with the ability to export to the entire US industry.
- Relative project spend on supply area - this portion of the project spend typically accounts for around 10% of total project costs.
- Investment case – A high level of investment and a sizeable long-term US market would be required to establish a nacelle assembly in MA.

Discussion

As with blade manufacturing, there is a gap in US supply to the industry. If MA could attract a major OEM nacelle assembly facility, this could support growth of a secondary supply chain. Incentives could be used to attract the manufacturer as the investment is large and by showing a willingness to co-invest in success MA would demonstrate further commitment to the offshore wind industry. The goal would be to form a cluster and both Tier 1s and developers would fully support such an effort. Suitably located land adjacent to a port is at a premium and would likely require significant refurbishments and modifications.

The establishment of a nacelle assembly plant in the state would provide significant opportunities for those in the manufacturing and services sector, both in nacelle assembly and in its component supply chain. The survey phase of this study has shown that there is an increased and wide-ranging set of skills that could be utilized to support these areas.

Although the requirements for suppliers are strict to achieve (turbine OEMs tightly control subcontracting opportunities and parts are generally standardized limiting opportunities for new suppliers) there may still be significant supporting supply chain opportunity. Nacelle components such as control and communication systems, HVAC, lighting, cabling, and secondary steel and machined parts such as brackets, plating, handrails, flooring and ladders could be supplied by MA companies.

9.2.3 Tower

Assessment

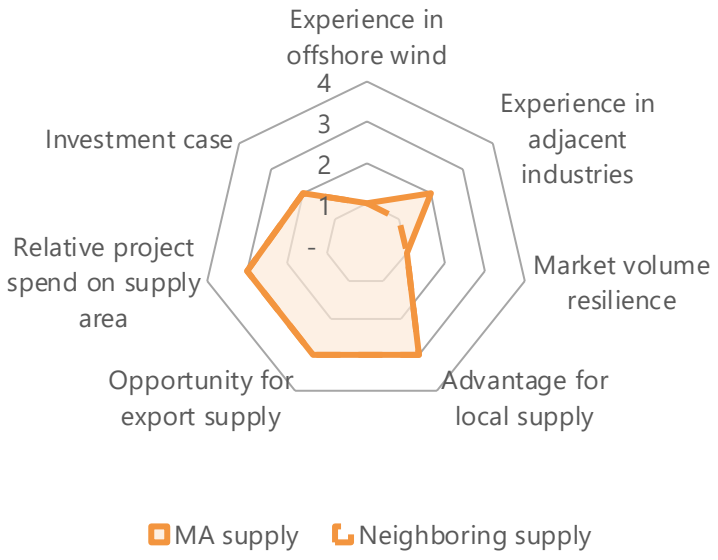


Figure 9-8 Assessment of MA and neighboring state tower supply opportunity

- Experience in offshore wind - Major turbine OEMs will procure towers as a sub-contract to the turbine supply contract, however there are currently no tower manufactures in MA or New England.
- Experience in adjacent industries – While sub-supply opportunities will exist, particularly further down the supply chain (Tier 2 or 3) to support tower internals secondary steel manufacturing, the historically absent heavy steel manufacturing industry in New England means there is no clearly established base from an adjacent industry. Onshore wind tower fabrication has typically been established around the Gulf Coast and Great Lakes.
- Market volume resilience – Offshore wind towers are bespoke to the OSW turbines and are significantly larger than onshore WTG towers. The long-term success of an offshore wind towers facility would be entirely reliant on the offshore wind project pipeline.
- Advantage for local supply – Local supply of towers would reduce logistical challenges associated with marshalling of components.
- Opportunity for export Supply – A tower fabrication facility can serve a wide geographical market. With the expected volume of projects in the north east there may be appetite for an MA supplier, however the planned tower manufacturing facility at the Port of Albany will provide competitive supply to the region.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 1.5% of total project costs.
- Investment case – A high level of investment and long-term confidence in obtaining suitable market share of the future project pipeline would be required to establish a tower fabrication facility assembly in MA.

Discussion

Towers for offshore WTGs are welded rolled steel cans. They are typically blasted, and surface finished (painted or coated) inside and out. Beyond manufacturing of the tower structures there are also opportunities for the supply of tower internal components where there is need for secondary steel items such as ladders, platforms, handrails, cable trays and electrical equipment including cables, lighting and heating, ventilation and air conditioning systems. This represents an opportunity for the firms identifying as having capabilities in the manufacturing and fabrication sector.

Manufacturing and fabrication firms were asked what share of their supplies/services come from inside the state, outside the state, and outside the country. The respondents report that an average of 73 percent of their suppliers and/or vendors are located in Massachusetts; less than 2 percent on average were located outside the country, including winches and specialty parts. Thus should a tower manufacturing facility be located in state, or towers for MA offshore wind projects be finished at local quayside, there is likely a strong secondary supply chain for components.

9.3 Balance of Plant Supply

Balance of plant covers the non-turbine related wind farm infrastructure, such as cables, substations and foundations.

9.3.1 Export Cables

Assessment

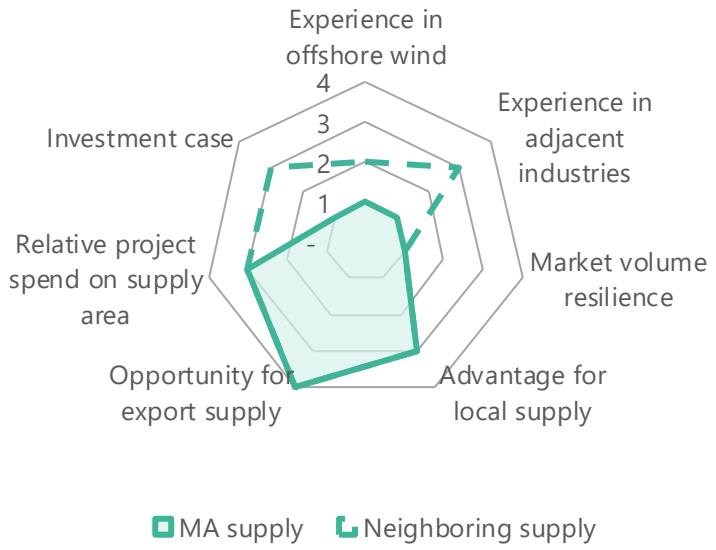


Figure 9-9 Assessment of MA and neighboring state export cable supply opportunity

- Experience in offshore wind – MA companies have no experience in delivering high voltage cables for the offshore wind industry nor have the facilities currently to serve future demand.
- Experience in adjacent industries – There do not appear to be companies in adjacent industries with strong capability to transfer to supply this area. Connections, terminations and cable protection are likely to be sourced elsewhere.
- Market volume resilience – There is limited demand for high voltage submarine cables in local adjacent sectors.
- Advantage for local supply – Local supply of cables would significantly reduce logistical costs and challenges associated with expense of specialist vessels equipped for cable handling.
- Opportunity for export supply – An export cable facility would serve a wide geographical market.

- Relative project spend on supply area - This portion of the project spend typically accounts for around 3% of total project costs.
- Investment case – A high level of investment and market confidence in offshore wind would be required to establish an export cable manufacturing facility in MA.

Discussion

Given the volume of projects in the north east there could be appetite for a facility to be located in MA with ability to export to the wider US industry. However, competition for this market will come from other states. Typical export cable suppliers include Nexans, Prysmian, LS Cable, NKT and JDR Cables. Some of these suppliers have established facilities in the US elsewhere (Nexans in North Carolina for example) and while the size of the opportunity is significant the investment in a new fabrication facility will be high.

It is understood that Marmon Utility (based in CT and NH) are actively pursuing opportunities for subsea cable supply to the offshore wind industry.

9.3.2 Array Cables

Assessment

Figure 9-10 Assessment of MA and neighboring state array cable supply opportunity

- Experience in offshore wind – MA companies have no experience in delivering high voltage cables for the offshore wind industry nor have the facilities currently to serve future demand.
- Experience in adjacent industries – There do not appear to be companies in adjacent industries with strong capability to transfer to supply this area. Connections, terminations and cable protection are likely to be sourced elsewhere.
- Market volume resilience – There is limited demand for high voltage submarine cables in local adjacent sectors.
- Advantage for local supply – Local supply of cables would significantly reduce logistical costs and challenges associated with expense of specialist vessels equipped for cable handling.
- Opportunity for export supply – An export cable facility would serve a wide geographical market.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 1% of total project costs.
- Investment case – A high level of investment and market confidence in offshore wind would be required to establish an export cable manufacturing facility in MA.

Discussion

Given the volume of projects in the north east there could be appetite for a facility to be located in MA with ability to export to the wider US industry. However, competition for this market will come from other states. Typical export cable suppliers include Nexans, Prysmian, LS Cable, NKT and JDR Cables. Some of these suppliers have established facilities in the US elsewhere (Nexans in North Carolina for example) and while the size of the opportunity is significant the investment in a new fabrication facility will be high.

It is understood that Marmon Utility (based in CT and NH) are actively pursuing opportunities for subsea cable supply to the offshore wind industry.

9.3.3 Foundations

Assessment

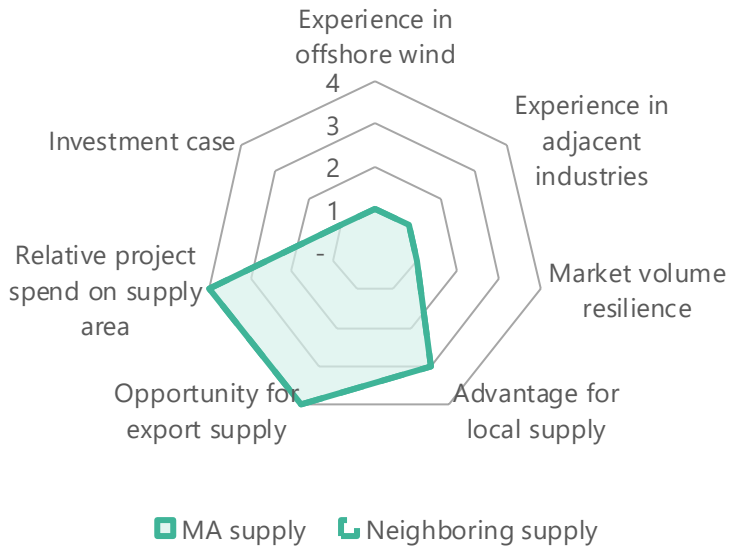


Figure 9-11 Assessment of MA and neighboring state foundations supply opportunity

- Experience in offshore wind - Major offshore foundation fabrication yards (for jackets, monopiles or transition pieces) are not present in MA. In 2010 Mass Tank were announced as a provider of monopiles for the Cape Wind project before the deal collapsed.
- Experience in adjacent industries – While specific opportunities do exist, particularly further down the supply chain (Tier 2 or 3) to support secondary steel manufacturing and fabrication needs, the historically absent heavy steel manufacturing industry in New England reduces the opportunity for the future production of foundations in the state.
- Market volume resilience – Offshore wind foundations are bespoke to the offshore environment and synergies and support are normally sought from oversees or the oil and gas industry. Company success in this sector would be entirely reliant on the offshore wind industry.
- Advantage for local supply – Local supply of foundation would significantly reduce logistical challenges associated with marshalling of components.
- Opportunity for export supply – A foundation fabrication facility would serve a wide geographical market. Given the volume of projects in the North East there should appetite for a facility to be located in MA with ability to export to the entire US industry.

- Relative project spend on supply area - This portion of the project spend typically accounts for around 6-8% of total project costs.
- Investment case – A high level of investment would be required to locate and establish a foundation fabrication facility in MA.

Discussion

If MA could attract a major foundation fabrication facility, this could support growth of a secondary supply chain. Suitably land adjacent to a deep-water port without air draft restriction is at a premium and would likely require significant refurbishment and modifications.

Supply of secondary components to such a facility would present a significant opportunity for MA based companies. Supply of steel sub-components could include machined and fabricated items such as railings, barriers, platform, J-tubes, boat interface steelwork, brackets, plating, handrails, flooring and ladders. The survey phase of this project has shown that there is an increased and wide-ranging set of skills that could be utilized for these purposes. MA companies could be in a position to transport these items to neighboring state facilities as they are largely rail and road transportable.

Although competition would be high between local suppliers the primary foundation contract is likely to be more open to widening subcontracting opportunities to local suppliers of components and services in an effort to increase local project spend. The recent survey feedback has shown there is a significant supporting industry in this sector that wasn't obvious at the start of this study.

9.3.4 Offshore Substation

Assessment

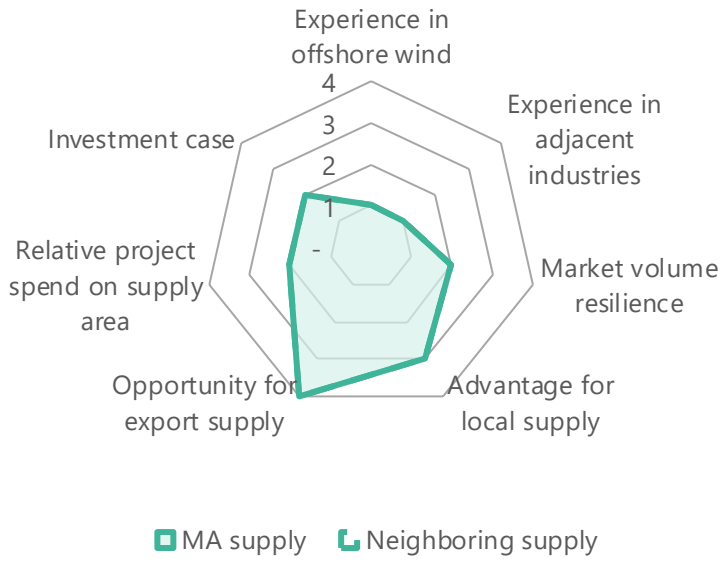


Figure 9-12 Assessment of MA and neighboring state offshore substation supply opportunity

- Experience in offshore wind - Substation electrical infrastructure OEMs have presence in MA but no manufacturing facilities in-state.
- Experience in adjacent industries – There is no clear experience in adjacent industries for the supply of either the electrical infrastructure or the offshore substation foundation.
- Market volume resilience – Companies manufacturing electrical infrastructure would look to supply other industries in addition to offshore wind.
- Advantage for local supply – Supply of offshore substation electrical infrastructure is likely in part to still come from Europe so local capability would reduce logistics costs. For offshore substation foundations there is less competitive advantage for a local supplier when structures can be produced in fabrication yards around the Gulf of Mexico.
- Opportunity for export supply – Electrical infrastructure manufacturing capability would serve a wide geographical market. There is less logic for export of substation foundations where these can be supplied from US fabrication yards around the Gulf of Mexico.
- Relative project spend on supply area - This portion of the project spend typically accounts for 3% of total project costs, with around 1.5% on the substation topside equipment and 1.5% for the foundation substructure.

- Investment case – Establishing a facility to manufacture complex electrical infrastructure for offshore substations would require a sizeable long-term project pipeline.

Discussion

While there are some synergies for the electrical infrastructure and electrical aspects of onshore substations, the existence of specialist expertise in the manufacturing of complex components with tight tolerances and supplying global markets means there may not be strong business case for new facilities. Despite strong US offshore wind capacity targets in place relatively few substations are required.

The offshore substation foundations (likely a large jacket structure) are analogous with those required in the oil and gas sector. Fabrication of offshore substation foundations is thus likely to be suited to established yards (such as Gulf Fabrications and Kiewit) in the Gulf of Mexico. There is less logic to MA based companies supplying secondary components as with turbine foundations where strong competition exists near the established fabrication yards, but some secondary steel structures can be fabricated away from the site of the main substructure and integrated at a staging facility prior to installation.

9.3.5 Onshore Substation

Assessment

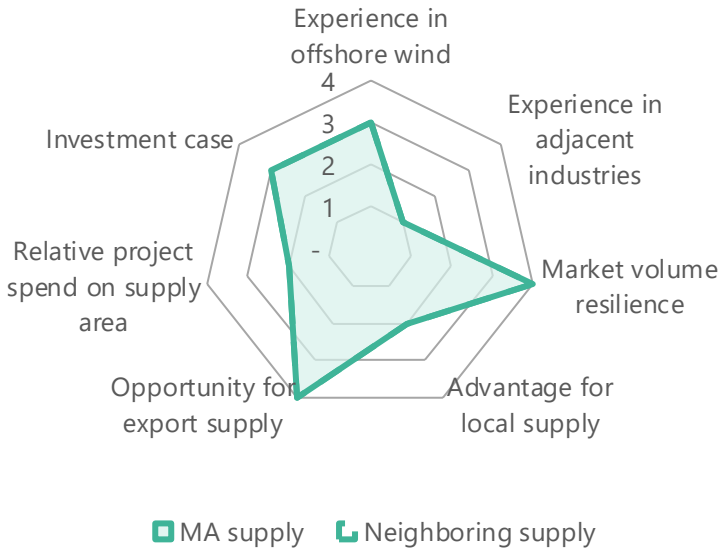


Figure 9-13 Assessment of MA and neighboring state onshore substation supply opportunity

- Experience in offshore wind - Substation electrical infrastructure OEMs have presence in MA but no manufacturing facilities in-state.
- Experience in adjacent industries – There appears to be limited experience in the supply of onshore electrical infrastructure in-state. However, those that do supply onshore grid transmission projects should be well positioned to support the offshore wind industry.
- Market volume resilience – Companies supporting the supply of onshore substations will be largely established prior to the emergence of the US offshore wind industry and will support sectors beyond offshore wind.
- Advantage for local supply – Local supply of electrical components would reduce logistical challenges associated with delivery of components, although components would likely be easily transportable by rail or road.
- Opportunity for export supply – As components are transportable, a supply chain supporting the electrical component supply of an onshore substation has the potential to serve a wide geographic market.
- Relative project spend on supply area - this portion of the project spend typically accounts for around 1% of total project costs.
- Investment case – A low level of investment would be required to establish electrical component supply in MA.

Discussion

There may be opportunity to establish a supply chain for onshore electrical infrastructure, however, the requirements for supply to offshore wind projects are not unique nor needed in high volume and so it is likely that this will come from established suppliers elsewhere.

There are likely companies situated in MA, supporting adjacent industries, that have capability to support. However, these have not been identified to date. McPhee Electric in Connecticut supported the onshore substation works for the Block Island project.

9.4 Installation & Commissioning

The installation and commissioning category includes the services contracted to construct an offshore wind project. These elements can be Tier 1 or Tier 2 packages, with the exception of ports contracts which are typically Tier 2 or Tier 3.

9.4.1 Turbine Installation

Assessment

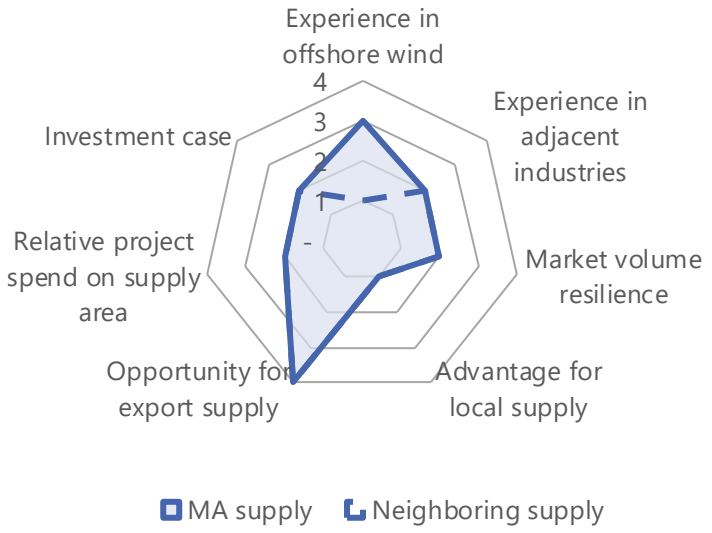


Figure 9-14 Assessment of MA and neighboring state turbine installation opportunity

- Experience in offshore wind – DEME Offshore has recently established a presence in Boston to support the turbine installation of Vineyard Wind.
- Experience in adjacent industries – Some aspects of the onshore construction sector could be used to support the installation of offshore wind WTGs such as onshore staging and marshalling including supply of lifting frames and rigging. Due to the requirements of the Jones Act, the market is still currently looking to establish the 'norm' for WTG installation. Due to the absence of a Jones Act compliant jack-up vessel for WTG installation, a feeder barge method is currently the preferred solution. This presents an opportunity for the supporting marine industry to play a limited role.

- Market volume resilience – While turbine installation heavy lift vessels can support offshore and quayside lifting operations in other sectors, the market trend has been to design vessels geared towards supporting the offshore wind market.
- Advantage for local supply – WTG T&I companies are multi-national and support projects around the globe. There is no particular advantage for them to be located in MA. Locality can be advantage to partnering with local barge supplier or marshalling yards.
- Opportunity for export supply – Conversely, WTG T&I vessels can support projects globally.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 1% of total project costs.
- Investment case – Long-term confidence in the US offshore wind market would be required for a MA based company to commission a Jones Act compliant turbine installation vessel.

Discussion

The opportunity for MA in this particular sector appears low, where focus should likely instead be on developing word-class ports and maritime logistics to support the WTG installation. This availability of supporting infrastructure will ensure multi-national T&I companies use MA to support their contracts in the north east.

The opportunity for local supply will likely be in providing added value through project management and vessel mobilization capability. For MA and neighboring state projects there will also be a need for ports, CTVs and technicians to support turbine commissioning. Milton Cat in MA have been contracted to provide temporary power during installation and commissioning of the Vineyard Wind project.

9.4.2 Foundation Installation

Assessment

Figure 9-15 Assessment of MA and neighboring state foundation installation opportunity

- Experience in offshore wind – DEME Offshore has recently established a presence in Boston to support the turbine installation at Vineyard Wind.
- Experience in adjacent industries – Due to the requirements of the Jones Act, the market is still currently looking to establish the 'norm' for turbine foundation installation. Due to the absence of a Jones Act compliant jack-up vessel for foundation installation, a feeder barge method is currently the preferred solution. This presents an opportunity for the supporting marine industry to play a limited role.
- Market volume resilience – While offshore heavy lift vessels supporting the installation of foundations can support offshore and quayside lifting operations in other sectors, the requirement from the offshore wind sector is likely to be the primary driver for the construction of any new Jones Act compliant vessel.
- Advantage for local supply – Foundation T&I companies are multi-national and support project around the globe. There is no particular advantage for them to be located in MA. Locality can be advantage to partnering with local barge suppliers or marshalling yards.
- Opportunity for export supply – Conversely, T&I vessels can support projects globally.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 2.5% of total project costs.

- Investment case – Long-term confidence in the US offshore wind market would be required for a MA based company to commission a Jones Act compliant foundation installation vessel.

Discussion

The opportunity for MA in this particular sector is low. Focus should be on developing word-class ports and maritime logistics to support the foundation installation such as the MassCEC New Bedford Marine Commerce Terminal. This availability of supporting infrastructure will ensure multi-national T&I companies use MA to set up base to support their contracts in the north east.

9.4.3 Subsea Cable Installation

Assessment

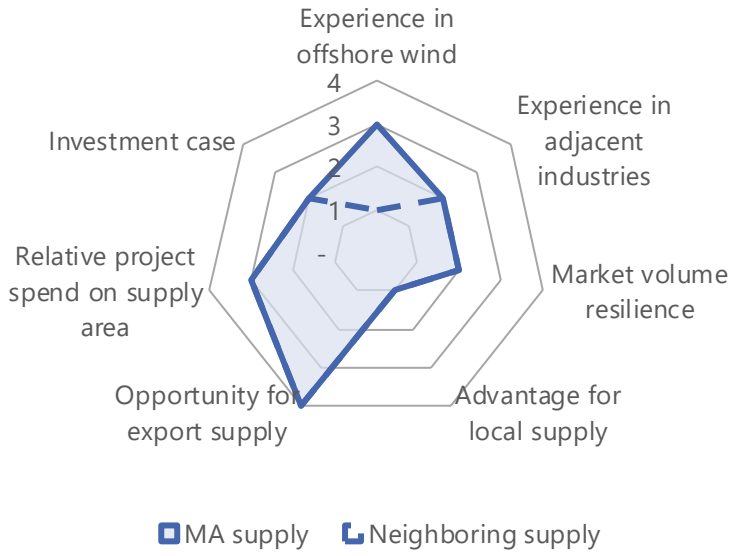


Figure 9-16 Assessment of MA and neighboring state subsea cable installation opportunity

- Experience in offshore wind – DEME Offshore has recently established a presence in Boston to support the turbine installation at Vineyard Wind and also have subsea cable installation capability and experience in offshore wind.
- Experience in adjacent industries – Experience in adjacent maritime industry is limited to provision of subsea inspection services.
- Market volume resilience – There is need for installation of submarine cables in other sectors, but the requirement in offshore wind is likely to be significant.

- Advantage for local supply – There is no strong logistical benefit to local supply of cable installation. Due the costs associated with cable handling it is typically the case that subsea cables are installed directly from the manufacturing facility.
- Opportunity for export supply – Cable installation vessels can supply projects globally.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 3-5% of total project costs.
- Investment case – Confidence in the US offshore wind market would be required for a MA based company to commission a Jones Act compliant cable installation vessel.

Discussion

The opportunity for MA in this particular sector is low, with few companies listed in the database with the capability to support subsea cable installation. While it is unlikely that developing local subsea cable installation capability will be a priority, there may some opportunity for local MA suppliers to support with inspection and commissioning.

9.4.4 Offshore Substation Installation

Assessment

Figure 9-17 Assessment of MA and neighboring state offshore substation installation opportunity

- Experience in offshore wind – DEME Offshore has recently established a presence in Boston to support the turbine installation at Vineyard Wind.

- Experience in adjacent industries – Vessels used to provide single heavy lifts of large topside modules or jacket installation come from the oil and gas industry or support turbine foundation installation in offshore wind. Electrical testing and commissioning services may come from adjacent sectors.
- Market volume resilience – Offshore heavy lift vessels supporting the installation of substation foundations can support offshore and quayside lifting operations in other sectors.
- Advantage for local supply – Heavy lift vessel operators are multi-national and support project around the globe. There is no particular advantage for them to be located in MA.
- Opportunity for export supply – Heavy lift vessels can support projects globally.
- Relative project spend on supply area - This portion of the project spend typically accounts for around 1% of total project costs.
- Investment case – It is unlikely new a new vessel will be commissioned to support offshore substation installation where this capability can be met from existing supply. Long-term confidence in the US offshore wind market would be required for a MA based company to commission a Jones Act compliant foundation installation vessel.

Discussion

The opportunity for MA in this particular sector is low. Focus should be on developing word-class ports and maritime logistics to support the offshore substation installation such as the MassCEC New Bedford Marine Commerce Terminal. This availability of supporting infrastructure will ensure multi-national T&I companies use MA to set up base to support their contracts in the north east.

9.4.5 Onshore Construction

Assessment

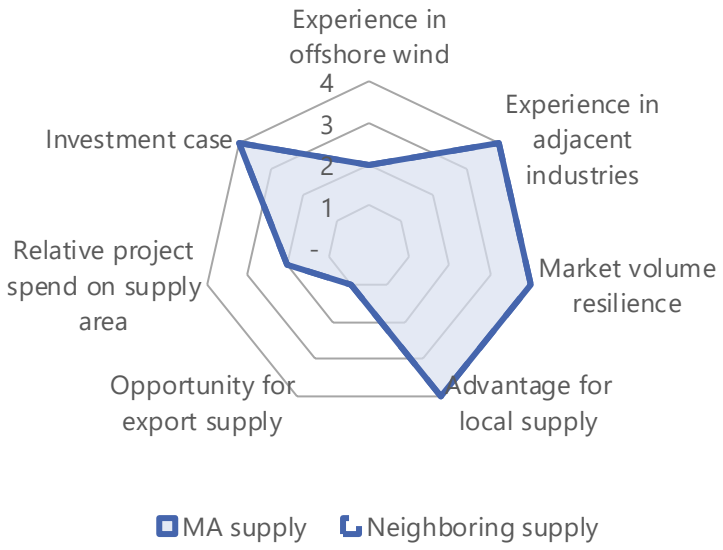


Figure 9-18 Assessment of MA and neighboring state onshore construction opportunity

- Experience in offshore wind – There is low experience in the offshore wind sector among MA and neighboring state onshore construction contractors, however in this area, lack of specific offshore wind project experience is not a barrier to supplying future projects.
- Experience in adjacent industries – Onshore civil infrastructure construction firms based in Massachusetts should be well positioned to support the onshore construction requirements of an offshore wind farm.
- Market volume resilience – Companies supporting onshore construction for an offshore wind project will support a wide range of other infrastructure projects.
- Advantage for local supply – Local civil construction companies are likely to be contracted.
- Opportunity for export supply – Local civil construction companies are likely to be contracted.
- Relative project spend on supply area - This portion of the project spend typically accounts for less than 1% of total project costs.
- Investment case – Companies in MA are already fully capable of providing support so no additional investment to supply is necessary.

Discussion

Onshore construction is likely to be an area where MA suppliers emerge with strong capability to support, although the skill sets used are not specific to offshore wind. With lease areas supporting multi-phased developments, MA firms are well placed to capture further construction work for future phases.

The existing database and survey work to date has identified numerous companies that can support this sector including 23 firms that identify as having construction and logistics management and 24 that identify has having capability in land-based construction.

9.4.6 Ports & Logistics

Assessment

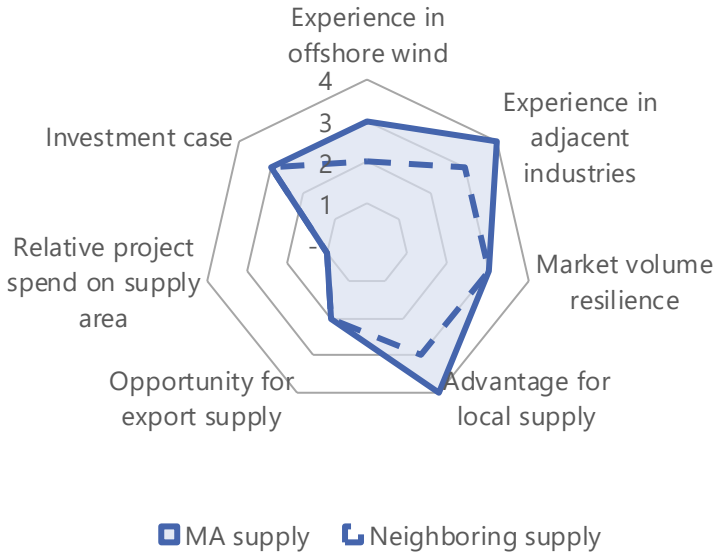


Figure 9-19 Assessment of MA and neighboring state ports and logistics opportunity

- Experience in offshore wind – While the New Bedford Marine Commerce Terminal has only supported development surveys to date it is lined up to support both Vineyard Wind and Mayflower Wind as the primary component staging and installation base for the projects.
- Experience in adjacent industries – There are multiple companies in the adjacent marine industry supply chain that have capability to support the offshore wind industry.
- Market volume resilience – Expanded port infrastructure could be used to support other industries but few have the same requirement as commercial scale offshore wind projects.

- Advantage for local supply – Local supply provides increased logistical benefit due to shorter transiting times to the offshore wind project location, and the NBMCT is due to gain significant experience from supporting multiple US projects. However, some components may be installed directly from manufacturing facilities.
- Opportunity for export supply – Installation and staging ports with strong capability can be used to support projects across a wide geographical area, although there will be logistical benefit to local supply where available.
- Relative project spend on supply area - This portion of the project spend typically accounts for less than 1% of total project costs.
- Investment case – Project developers have typically been willing to provide some investment and share risk in developing installation ports.

Discussion

Early offshore wind projects navigating the Jones Act requirement has restricted port staging and marshalling opportunities, where the first projects are likely to receive components from overseas without ever reaching US mainland. However, NBMCT is a major strength of the MA offshore wind supply chain, as it is currently the only facility in the US that is designed specifically for the staging of offshore wind projects, and is under agreement to serve as the primary staging and deployment base of the construction and installation phase for the Vineyard Wind and Mayflower Wind projects.

In addition to this major piece of infrastructure in New Bedford, other port facilities and waterfront spaces around the state have been identified and could potentially be acquired or leased and improved upon through industry-led investment to become suitable facilities for a number of offshore wind activities. These include the Brayton Point Power Plant facility in Somerset, along with multiple other options in the Fall River, Somerset, New Bedford, Boston and Quincy areas, totalling 18 facilities in all.

Other ports in the north east region that will likely compete for contracts related to staging and marshalling include two ports from Connecticut including the Port of Bridgeport, which will act as the staging port for the Park City Wind project being developed by Vineyard Wind (Copenhagen Infrastructure Partners and Avangrid Renewables) and the Port of New London, CT, which has entered into a partnership with the offshore wind developer Ørsted and their partner Eversource for port improvements needed for the Revolution Wind project. Additionally, the Port of Providence and Port of Quonset in Rhode Island are competing in this area. The Port of Portsmouth, NH, which has a large amount of marine industry as a result of the presence of the US Navy in the port may also support offshore wind activity in the future. While this port is further from the current identified offshore wind lease areas it is well placed to support future projects in the Gulf of Maine.

In addition to the MA port infrastructure to support offshore wind projects, there comes significant opportunity for local companies to provide port and logistics services including security, utilities, fuel bunkering, stevedoring, cranes, handling, forklifts, SPMTs, trailers, vessel maintenance, ships agent, towage, and waste removal. Provision of these services is not limited to the project installation phase, where smaller ports in MA may aid in these logistical services to support the development surveys and wind farm O&M stages.

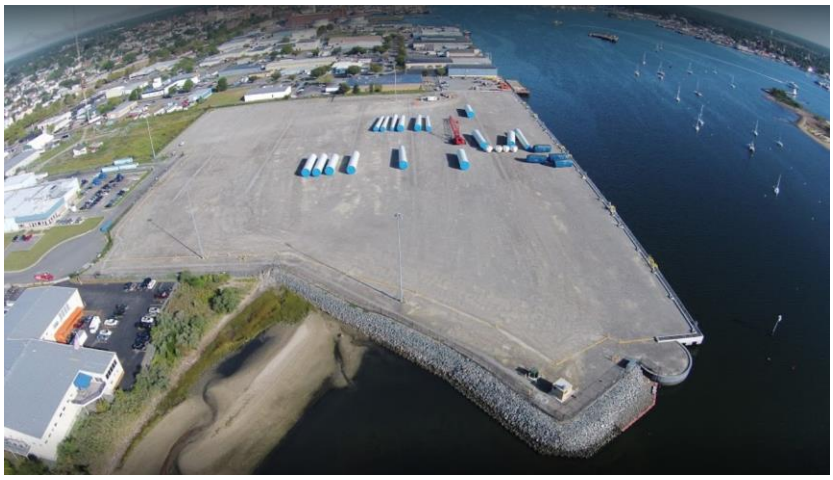


Figure 9-20 New Bedford Marine Commerce Terminal

9.5 Operations & Maintenance

The operations and maintenance (O&M) category includes the products and services required to optimize and sustain the performance of offshore wind projects over their lifetimes. Wind farm O&M is typically led by one of the project developers in the lead operator role from an operations base close to the project.

9.5.1 Operations

Assessment

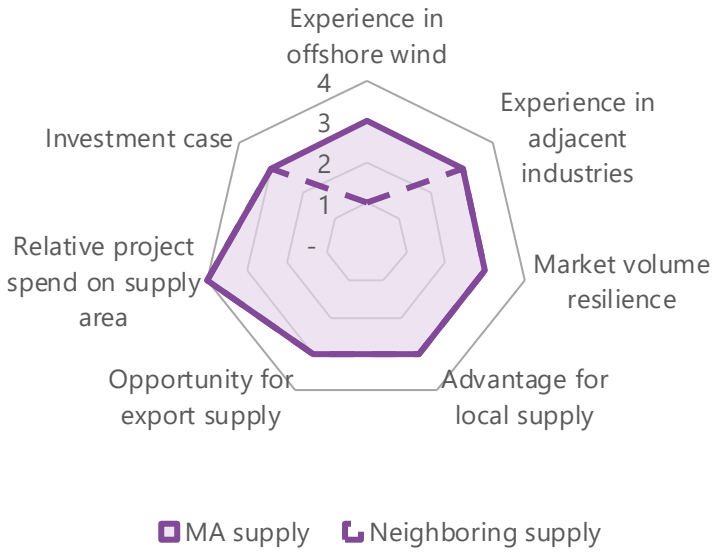


Figure 9-21 Assessment of MA and neighboring state wind farm operations opportunity

- Experience in offshore wind – Several project developers have a presence in MA.
- Experience in adjacent industries – Many MA companies working in adjacent marine and logistics sectors will be able to support offshore wind projects without additional investment. Suppliers looking to expand capability to offer bespoke offshore wind training or software services will need to understand specific sector needs.
- Market volume resilience – There is overlap in the services provided to project operators with the marine operations and onshore wind sectors.
- Advantage for local supply – For provision of operations software tools there is no competitive advantage to locality, but operations typically occur at a local base where locality of support services is advantageous.

- Opportunity for export supply – Provision of software and digital services to support wind farm operations are not tied to location, and local training of technicians can be of benefit to non-local projects.
- Relative project spend on supply area - O&M represents a long-term opportunity for supply chain. This portion of the project spend typically accounts for around 10-15% of total project costs.
- Investment case – Investment required to develop capability in operations services is relatively low.

Discussion

While day-to-day and long-term operations planning and execution is carried out by the project lead operator, there are opportunities for MA companies to support operations via provision of control room software for management of tasks and real time monitoring and analysis of performance data, training and certification of technicians, and onshore and offshore logistics support. The high number of MA companies listed in the MassCEC database represent a diverse range of potential MA suppliers with capabilities across these areas.

With little installed offshore wind capacity in the US and operations stage contracting typically not occurring until late in the project development process there have been few opportunities to date for MA companies to engage with the sector and demonstrate capability. As projects become operational (particularly local projects) it can be anticipated that a greater number of suppliers will be identified to support offshore wind farm O&M.

9.5.2 Turbine Inspection & Maintenance

Assessment

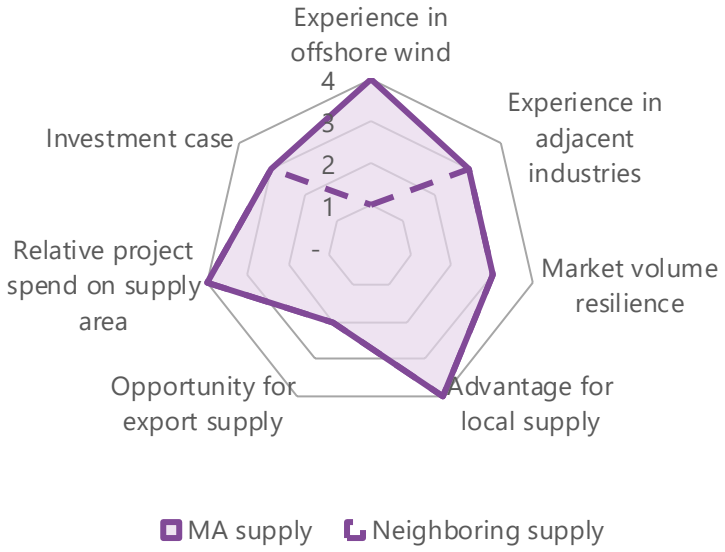


Figure 9-22 Assessment of MA and neighboring state turbine maintenance opportunity

- Experience in offshore wind – The three major offshore wind turbine OEMs (who typically take responsibility for turbine inspection, repair and maintenance during the initial five-year warranty period) have a presence in MA.
- Experience in adjacent industries – Engineering and inspection companies may see provision of turbine technicians and inspection and repair services as an opportunity for diversification, where investment in training and certification will be required. Companies with turbine inspection capability to serve the onshore wind sector can also transition to working offshore with appropriate training and certification.
- Market volume resilience – Companies moving to support offshore wind O&M will anticipate being able to provide services long-term.
- Advantage for local supply – There is a significant logistics benefit to local supply where mobilization costs can be minimized and the ability to attend to repairs quickly reduces generation downtime.
- Opportunity for export supply – Specialist O&M provision can be mobilized from further afield.
- Relative project spend on supply area - O&M represents a long-term opportunity for supply chain. This portion of the project spend typically accounts for 15-20% of total project costs.
- Investment case – Companies investing in own capability to provide O&M will take confidence from the long-term opportunity.

Discussion

While responsibility for turbine inspection, repair and maintenance will sit with the turbine OEM for at least the first five years of the operational lifetime, subcontracting opportunities will arise for inspection and repair of turbine mechanical, electrical and auxiliary components, as well as blade inspection that may be undertaken via rope access or by drones. The turbine O&M is critical to keep asset downtime as low as possible.

With little installed offshore wind capacity in the US and operations stage sub-contracting for turbine maintenance typically not occurring until the project is already operational there have been few opportunities to date for MA companies to engage with the sector and demonstrate capability. As projects become operational (particularly local projects) it can be anticipated that a greater number of suppliers will be identified to support offshore wind farm O&M.

9.5.3 Balance of Plant Inspection & Maintenance

Assessment

Figure 9-23 Assessment of MA and neighboring state balance of plant maintenance opportunity

- Experience in offshore wind – Several MA companies have gained some early experience in supporting inspection, maintenance and service of the Block Island project, although only relatively minor involvement to date.
- Experience in adjacent industries – The marine and subsea engineering services industry is well placed to support this function.
- Market volume resilience – Companies moving to support offshore wind O&M will anticipate being able to provide services long-term.
- Advantage for local supply – There is a significant logistics benefit to local supply where mobilization costs can be minimized and the ability to attend to repairs quickly reduces generation downtime.
- Opportunity for export supply – Specialist O&M provision can be mobilized from further afield.
- Relative project spend on supply area - O&M represents a long-term opportunity for supply chain. This portion of the project spend typically accounts for 10-15% of total project costs.
- Investment case – Companies investing in own capability to provide O&M will take confidence from long-term opportunity.

Discussion

Balance of plant inspection, repair and maintenance covers a diverse range of onshore and offshore (subsurface and topside) structural, mechanical and electrical needs, as well as support to access the wind farm and provision of tools and equipment. There are over 30 MA companies in the MassCEC database with capability to support this function, however, many of these have gained their experience predominantly or exclusively in onshore maintenance and servicing.

The Rhode Island marine industry has already produced two companies (Atlantic Wind Transfers and WindServe Marine) offering CTVs specifically for the offshore wind sector. Both of these companies had CTVs manufactured in Rhode Island (Blount Boats and Senesco Marine). V2 Subsea and E.W. Audet & Sons are Rhode Island companies that have provided inspection services to US offshore wind projects, in ROV subsea inspection and electrical inspection respectively.

With little installed offshore wind capacity in the US and operations stage contracting for balance of plant maintenance typically not occurring until the project is already operational there have been few opportunities to date for MA companies to engage with the sector and demonstrate capability. As projects become operational (particularly local projects) it can be anticipated that a greater number of suppliers will be identified to support offshore wind farm O&M.

9.6 Decommissioning

9.6.1 Decommissioning

Assessment

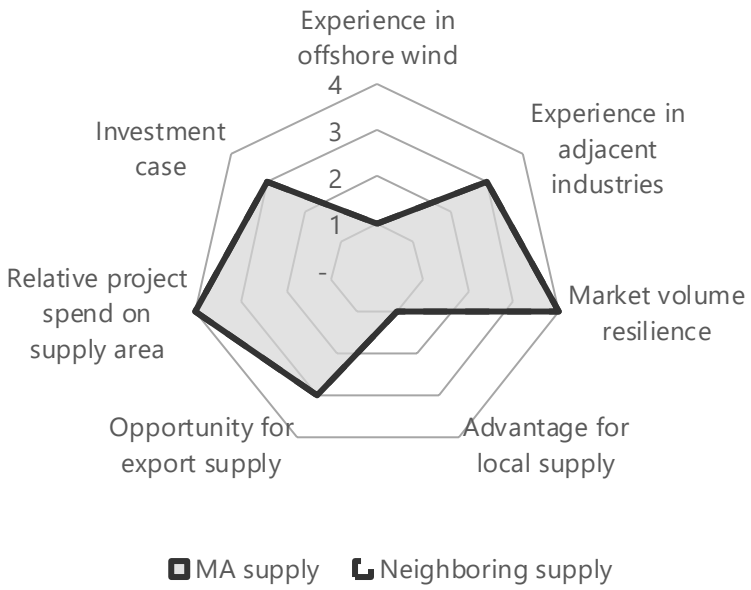


Figure 9-24 Assessment of MA and neighboring state decommissioning opportunity

- Experience in offshore wind – The lack of experience in offshore wind decommissioning is expected with services not likely to be required for 25+ years.
- Experience in adjacent industries – Some experience likely to come from adjacent marine industry.
- Market volume resilience – Scrap and salvage not exclusive to offshore wind.
- Advantage for local supply – Likely no significant competitive advantage to local supply.
- Opportunity for export supply – Where capability does emerge it is likely to service multiple east coast projects.
- Relative project spend on supply area - Expenditure on decommissioning has only been estimated to date as no commercial scale projects have required this. Estimated spend range at around 3-8% of total costs.
- Investment case – It is likely that most decommissioning activities will be carried out by existing suppliers, although technical solutions to the recycling of turbine blades still require investment.

Discussion

Few offshore wind projects globally have been decommissioned to date and supporting services are not anticipated to be required for 25+ years. There are 13 companies in database with marine, environmental and infrastructure background who may support this function in the future.

9.7 Sector Support

The Massachusetts education system is one of the strongest in the nation, a strength which translates into higher paid jobs than most. Private colleges have already begun developing courses or programs that are focused on offshore wind. While this is a strength for the state it generally will translate to jobs in the Professional Services and Project Development sector (Engineering, Permitting and Consulting). While this may be a good outcome that would consolidate the states position as leader in this sector it does not address the workforce labor requirements for areas requiring manual skills such as construction, manufacturing and fabrication.

It has been identified that there is a gap when it comes to access to offshore wind training (at all levels) in underrepresented or historically disadvantaged communities. MassCEC are working towards identified programs to start to close this gap.

Workforce development needs to be evaluated in terms of skill set, availability and timing. MA is especially strong in engineering and technical employees. There was no universal knowledge of the workforce training programs available in the state or the recruiting methods needed to grow the workforce. A common theme from the survey results was the need to train the workforce to meet the needs of the offshore wind industry. The timing of training needs to coincide with development of projects. MA needs to align its training (both offshore wind specific, such as GWO at MA Maritime Academy and task specific skills) to ensure workers are available when they are needed. As this may be a steep ramp, planning is a critical success factor. The Tier 1s and project developers are eager to support and provide input into the type of training and their need for workers.

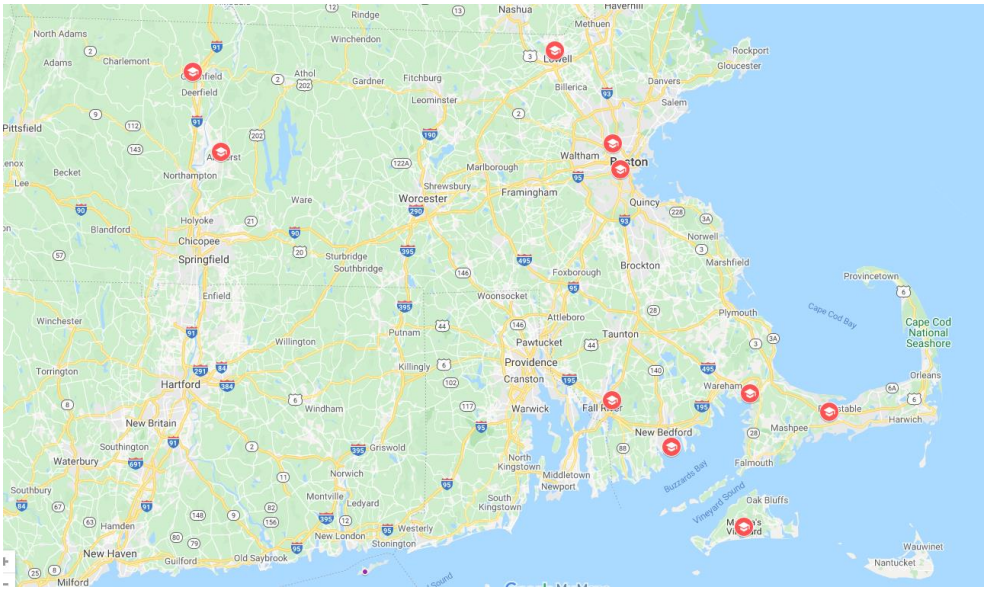


Figure 9-25 ***Interactive Map*** *of offshore wind training opportunities from WDI*

9.8 Summary Matrix

	Experience in offshore wind	Experience in adjacent industries	Market volume resilience	Advantage for local supply	Opportunity for export supply	Relative project spend	Investment case
Development and permitting	4	4	4	2	4	1	4
Surveys	4	4	3	3	3	1	4
Engineering & design	4	3	4	2	4	1	4
Project management	4	4	4	2	4	1	4
Rotor	1	2	2	3	4	3	2
Nacelle	1	1	1	2	4	4	1
Tower	1	2	1	3	3	3	2
Export cables	1	1	1	3	4	3	1
Array cables	1	1	1	3	4	2	1
Foundations	1	1	1	3	4	4	1
Offshore substation	1	1	2	3	4	2	2
Onshore substation	3	1	4	2	4	2	3
Turbine installation	3	2	2	1	4	2	2

	Experience in offshore wind	Experience in adjacent industries	Market volume resilience	Advantage for local supply	Opportunity for export supply	Relative project spend	Investment case
Foundation installation	3	2	2	1	4	3	2
Subsea cable installation	3	2	2	1	4	3	2
Offshore substation installation	3	2	2	1	4	2	2
Onshore construction	2	4	4	4	1	1	4
Ports and logistics	3	4	3	4	2	1	3
Operations	3	3	3	3	3	4	3
Turbine inspection and maintenance	3	3	3	4	2	4	3
BoP inspection and maintenance	3	4	3	4	2	4	3
Decommissioning	1	3	4	1	3	4	3

Figure 9-26 Summary of MA supply chain opportunity analysis

10 TASK C - MA SUPPLY CHAIN SUMMARY SWOT ANALYSIS

Strengths	Weaknesses
• Good experience in all project development categories that can be utilized on future projects. • Several project developers, turbine OEMs and Tier 1 suppliers have been attracted to locate in MA. • Two commercial scale offshore wind projects have chosen the NBMCT as the installation staging base, leveraging MA capability in ports and logistics services. • Strong higher education system producing high value lead technical and engineering workers.	• Current absence of significant manufacturing capability for high capital expenditure items. • Historically heavy steel fabrication capability has not been located in state. • No clear experience in adjacent industries being untapped. • Workforce labor gap still to be addressed (requirement for manual skills such as construction, manufacturing and fabrication) including to attain better representation for historically disadvantaged communities.

Opportunities	Threats
• The export supply opportunity remains high while the US supply chain is still to be firmly established, allowing for the possibility for an MA company to capture a significant US market share should manufacturing capability be established in state. • The MassCEC Wind Technology Testing Center could be leveraged to attract a blade manufacturing facility to MA. • Commercial scale projects being developed locally mean MA is well positioned to grow operational phase capability, where having early requirement for O&M skills and services could enable successful establishment of an O&M skills training hub.	• Dependency on US market volume to enable investment in facilities. • Strength of competing supply chain from established offshore wind markets. • Manufacturing facilities could be incentivized to locate in other states.

Massachusetts has a developing offshore wind supply chain. MA companies have capitalized of experience in existing adjacent industries and the ability to supply early US offshore wind projects to grow their capability. Early indications

from a nascent industry are that MA will be well positioned to develop strengths in supporting project development and O&M phases of the offshore wind project lifecycle and may have opportunity to host Tier 1 manufacturing.

The capability to provide project development services, including permitting, surveying and engineering design support, appears to stem from research and consultancy competencies native to MA. It is likely MA and neighboring state companies will continue to provide these kinds of services as the offshore wind sector develops, both to local projects and in support to projects along the US east coast.

The US offshore wind supply chain currently lacks dedicated offshore wind turbine and blade manufacturing facilities, where early commercial projects will be supplied form existing European plants. The decision for any turbine OEM to establish a US facility will depend on the relationship between project demand and their supply capacity at existing plant, and whether doing so improves their opportunity to win contracts including though either improved cost competitiveness or capability to support meeting any future local content requirements. Each of the three major offshore wind turbine OEMs have presence in MA putting the Commonwealth in a rare position among US states.

The long-term project demand requirements necessary to justify investment in a new turbine assembly facility are high and OEMs will likely need to forge new supply chain relationships where they are confident in supplier capability before committing to a new location. Each of the turbine OEMs supporting establishment of US blade manufacturing facilities is more likely given the lower levels of investment required. MA may be able to leverage the presence of the MassCEC Wind Technology Testing Center to attract one of the OEMs to locate nearby should a suitable quayside space be available.

Similarly to nacelle and rotor supply, there is a gap in US capability to supply towers for offshore wind projects. Although plans are in place for an offshore wind tower manufacturing facility in New York, tower manufactures are suppliers to all of the turbine OEMs and so the project pipeline is likely to be able to support several facilities operating at once, even if one turbine OEM takes a dominant position in the US market. Public sector investment or incentives to attract any or all of nacelle, blade or tower manufacturing in MA would also provide opportunity to build out the supply chain of supporting services of adjacent industries around any such facilities.

Domestic supply locations for the remaining balance of plant components are also yet to be set for the US offshore wind industry. It is likely each will be met through a combination of native US suppliers investing internally in capability to meet the needs of the sector and also in established suppliers from non-US markets investing in US manufacturing facilities. There are no clear MA based companies in adjacent sectors ready to transition to becoming Tier 1 balance of suppliers in offshore wind, although subsea cable supply capability may be established in Connecticut.

MA does benefit from excellent port facilities ready to support the offshore wind sector, with the New Bedford Marine Commerce Terminal chosen to support the installation of two commercial scale projects. With a growing project pipeline in the north east there may be case for further investment in port facilities that could support location of new component manufacturing or assembly facilities or be the base for wind farm installation or O&M activities. These could also enable established MA port and marine services providers to benefit from the offshore wind opportunity.

With the location of early commercial scale offshore wind projects in the US north east, MA and neighboring states will have an early opportunity to develop into O&M supply chain excellence hubs. Having multiple project developers and turbine OEMs present in MA can be leveraged to guide necessary skills and services development and provide direct employment and contracting opportunities for the supported workforce and supply chain.

11 TASK D - RECOMMENDATIONS

11.1 Market Development Recommendations

- Market 1 – A concerted and coordinated initiative by MA to launch a new "business pitch" to attract large manufacturers (OEMs or Tier 1s) would affirm that MA is very interested in the economic opportunities of offshore wind. If MA could attract a major OEM or Tier 1 manufacturing facility this in turn will drive the growth of Tier 2 and 3 suppliers, economic activity, and job creation as the production plant will serve as a major hub of supply chain development. In order to support this further, MA should work with neighboring states, RI and CT, to understand the potential support/services that could be provided to the large organization from the region. This will demonstrate that MA has gone through a robust exercise of understanding in-state strengths and give the incoming Tier 1 or OEM confidence their needs can be met on a regional level.
- Market 2 – Develop and implement a capability assessment and enhancement 'pilot' initiative. The purpose of this recommendation is to develop a Technical Assistance/Certification Program for MA-based businesses seeking to develop the competencies necessary to supply and provide services for the offshore wind energy industry. The program should include the development of questionnaires and materials for the application of interested businesses, eligibility and evaluation criteria, pre and post technical assistance assessments, procedures for how technical assistance and certification services will occur, and a detailed approach to allow participants to receive certification. If successful, the program should scale to provide support to all interested MA business and could be replicated in other states or regions.
- Market 3 – On an ad-hoc/as required basis, MassCEC should continue to provide support, guidance, and services to incoming international and other US businesses, including meet and greets and through custom business-to-business matchmaking support, serving as an ombudsman to connect to other state agencies and municipalities. This includes support for international trade delegations and continuing to foster productive relationships with European partners.
- Market 4 – Development of a 'clearing house' for contracting opportunities and support for "meet-the-buyer" events would be a high-value resource for both the offshore wind industry and the local supply chain. While developers and OEM/Tier 1 companies want to engage the local supply chain, they are having a difficult time in knowing where to start. Current databases of companies do not provide the level of detail necessary for substantive discussions to take place, which are essential in supply chain growth. Conversely, the local supply chain doesn't know how to access opportunities that may be available for them.
- Market 5 – Through the work completed in previous phases of this offshore wind supply chain project, multiple additional business and skillsets have been identified that could support the industry. Geographical information systems (GIS) can be used in the supply chain in many different ways, but the primary one is advanced visualization. Instead of just looking at spreadsheets or databases, users can have a visual and intuitive picture of what is going on in the supply chain at their fingertips. The biggest challenge to this is standardization of data; however, the work

done to translate the MassCEC OSW supply chain database to a standard taxonomy gives a solid foundation to build this from.

11.2 Investment Recommendations

- Investment 1 – The further development of MA port and harbor facilities for offshore wind is critically important for the industry. It is broadly acknowledged that the development of the New Bedford Marine Commerce Terminal was a big catalyst supporting the state's leadership in offshore wind. However, with potentially overlapping project construction schedules and bottlenecks as well as some limitations in laydown area at the Terminal, developers are likely to seek additional and/or alternative solutions in RI, CT or NY. Further investments in the redevelopment of port and harbor infrastructure for offshore wind marshalling and pre-assembly, manufacturing, and O&M would go a long way to ensure that MA remains a highly desirable and competitive location for offshore wind marine construction operations.
- Investment 2 – In order to attract and Wind Turbine OEM or major Tier 1, state financial incentives should be deployed to support attraction of the businesses to the state. In addition to currently available tools, MA should consider using public funding to leverage private investment in the redevelopment of key sites for manufacturing and production of turbine components and other balance of plant elements.
- Investment 3 – For established Tier 2 and 3 companies already doing business in MA that are motivated to enter the offshore wind supply chain but need support do so, financial incentives should be made available through grants or low interest loans should be made available to accelerate medium and small businesses ability to more rapidly be qualified to compete for contracts. A process should be established to screen eligible companies and could focus on re-tooling, workforce training or manufacturing upgrades, for example.
- Investment 4 – Identify and communicate existing funding opportunities. With multiple grants and funding opportunities available from different government and state organizations, it can be hard to track or even identify what is. A common platform for communicating opportunities for offshore wind funding or other technical assistance should be developed and launched.

11.3 Workforce Recommendations

- Workforce 1 – Local suppliers and labor groups would greatly benefit from enhanced communication regarding the certification and training requirements of the Tiers 1s and OEMs. Building on the MassCEC Career pathways tool (cleanenergyeducation.org), the connections between workforce training and employment across the lifecycle of the offshore wind projects could be identified and highlighted.
- Workforce 2 – The collaborative development of internships and pre-apprenticeship programs between developers, suppliers, skilled trades, and other groups would be an important action to better connect employment opportunities to local schools and colleges, community organizations, and others in order to meet industry needs and to help ensure uptake is diverse, equitable and inclusive.
- Workforce 3 – Workforce training initiatives, courses and programs should be better coordinated on a regional basis. This will help ensure consistency of training and credentialing across states and allow for more efficient flow

of both workers and instructors in the region. The ability of local skilled trade unions to be able to support other regional unions when demand exceeds the capacity of locals is an important aspect of the regionalization of the workforce. How project specific Project Labor Agreements will affect this goal is not yet known.

11.4 Innovation Recommendations

- Innovation 1 – Develop an innovation and incubator program to attract entrepreneurs/start-ups and connect them to the offshore wind industry, academic and research institutions, and other technology development assets. Distinct from the efforts of NREL and NOWRDC, the purpose of this concept is to nurture new ideas, technologies and processes to build on the Commonwealth's leadership in innovation. This program would serve as 'hub' for technology screening and enable the acceleration of commercialization of innovative solutions.
- Innovation 2 – Create and partner with research groups growing and advancing the ongoing POWER-US initiative. Collaboration and support to ongoing and new research initiatives will enable the knowledge base within the state and ensure R&D and innovations are viewed through a MA lens.
- Innovation 3 – Connect regional universities to leverage assets for offshore wind. Many universities have discrete programs and initiatives focused on various aspects of offshore wind from protype testing, workforce development, environmental monitoring, etc. In order to improve the offshore wind industry's understanding of the expertise, assets, and ongoing initiatives, a platform should be created to improve accessibility for the industry. This would increase efficiency in R&D and foster collaboration between universities and their ongoing scopes.
- Innovation 4 – The creation of knowledge transfer partnerships with European innovation hubs, such as UK Energy Research Centre, Offshore Renewable Energy Catapult, and Norwegian Centre for Offshore Wind Energy. There are significant lessons to be learned from European centers of technical excellence. This recommendation was seen as an important step but was not identified as a current high priority.

11.5 Policy Recommendations

- Policy 1 – MA should consider increasing the requirements for economic benefit commitments (i.e., "local content") in offshore wind procurements to accelerate growth of the offshore wind supply chain. If developers and their contractors are incentivized through the bid process to do more for the local supply chain, this will result in greater investment in economic and physical infrastructures as well as the education and talent of the local workforce. It is acknowledged that the price of the offshore wind energy would, in turn, be somewhat higher.
- Policy 2 – The establishment of formal agreements with neighboring states (RI, CT, NH, and ME) to support the development and growth of the offshore wind supply chain and supporting infrastructure is an action worth consideration. The assessment of neighboring states as part of this project is a step in the right direction and should be the seed for further conversations on the topic, with the view being a regional approach is greater than the sum of its parts. As the furthest advanced in the development of its offshore wind economy, MA has the opportunity to lead this collaboration ensuring that it is ultimately suited to their needs and requirements.

11.6 Summary

The tables below represent a summary of the recommendations identified during the workshops broken down in terms of the four broad designations as described in Section 2. These have been further prioritized to enable MassCEC to understand, relatively, the recommendations to action first.

11.6.1 Lower Difficulty/Higher Impact

RECOMMENDATION REF.	DESCRIPTION	RELATIVE PRIORITY
Market 2	**The development of a capability assessment and enhancement 'pilot' initiative**	**High**
Market 3	**Continuing the support to incoming businesses**	**High**
Workforce 1	**Enhanced communication of certification and training requirements for working with Tiers 1s and OEMs**	**Medium**
Investment 4	**The identification and communication of existing funding.**	**Medium**
Market 5	**GIS supply chain mapping**	**Low**

11.6.2 Higher Difficulty/Higher Impact

RECOMMENDATION REF.	DESCRIPTION	RELATIVE PRIORITY
Market 1	**The creation of a business pitch to attract large manufacturers, Tier 1s or OEMs**	**High**
Investment 1	**Further development of MA port and harbour facilities**	**High**
Investment 2	**Deployment of state financial incentives to attract a Wind Turbine OEM or major Tier 1 (purpose designed or currently available).**	**High**
Workforce 2	**Internships and pre-apprenticeship programs are developed in collaboration with developers and suppliers in order to meet industry needs**	**High**

RECOMMENDATION REF.	DESCRIPTION	RELATIVE PRIORITY
Market 4	'Clearing House' for contracting opportunities	Medium
Investment 3	Financial incentives should be made available through grants, low interest loans to enable MA businesses in offshore wind.	Medium
Innovation 2	Create and partner with research groups similar the ongoing initiative with POWER-US.	Medium
Innovation 3	Connect regional universities to leverage assets for offshore wind.	Medium
Innovation 1	Develop national incubator program	Low
Policy 1	Implement stricter local content rules within the state to accelerate growth of the offshore wind supply chain	Low
Policy 2	Establish a meaningful MoU with neighboring states (RI, CT and NH)	Low

11.6.3 Lower Difficulty/Lower Impact

RECOMMENDATION REF.	DESCRIPTION	RELATIVE PRIORITY
Innovation 4	Creation of knowledge transfer partnerships with European innovation hubs	Low

11.6.4 Higher Difficulty/Lower Impacts

RECOMMENDATION REF.	DESCRIPTION	RELATIVE PRIORITY
Workforce 3	Workforce training initiatives, coursed and programs to be coordinated on a regional basis.	Low

APPENDIX A INTERVIEW TEMPLATES

A.1 Developers

Subject Area 1	How do you define your major packages (WTGS, Foundation etc.)?
What are the packages as defined by your organization? How consistent are these packages across all your projects? Do packages change based upon PPA size and/or location (or other project characteristic)? Do you favor an EPCI or multi-contract based approach (or a mix of both)? Is the package breakdown driven at a project level or a corporate level?	
Subject Area 2	How do you influence Tier 2/3 supply chain procurement?
Do you identify locations for the Tier 1 suppliers? Do you identify supply chain partners and arrange introductions? Do you push local content requirements to the suppliers? What influence do you have in the selection of Tier 2/3 suppliers?	
Subject Area 3	What are your internal criteria for evaluating suppliers?
How would you describe your process for evaluating Tier 1 suppliers? Is part of the process looking at their supply chain network?	
Subject Area 4	Key challenges you perceive to achieving high local content on projects
Where do you expect local content to come from on your project? Are the local content requirements made clear to the Tier 1s? Is there typically flexibility in how local content is defined? How is it validated by the state?	
Subject Area 5	Understanding impact of PLAs on supply chain and local content metrics/KPIs
How are project labor agreements impacting the contracting of tier 1 packages? Is the local supply chains understanding of skilled labor and unions a key influence in contracting success factors? Are you negotiating PLAs on behalf of the project? Are Tiers 1s involved in the negotiations of PLAs?	
Subject Area 6	Strengths of Local Supply Chain
Rate each of the following in terms of strength of the MA supply chain (1 - Poor, 5 - Excellent): 1. Available skilled labor	

2. Engineering and Environmental Services 3. Operations and Maintenance 4. Offshore Construction 5. Ports 6. Raw material supply (secondary steel, rolled steel etc.) 7. Research and development 8. WTG and WTG component supply (inclusive of WTG towers) 9. Electrical infrastructure supply (onshore and offshore substation equipment) 10. Cables (Export cables and Inter Array Cables, including ancillaries.) How would you rate the strength of the existing OSW supply chain eco-system in MA? (1 - Poor, 5 - Excellent) Why? Where do you believe MA ranks in comparison to neighboring states in regard to strength and depth of the OSW supply chain? 1. MA 2. RI 3. CT 4. NY 5. NJ How does your rating of these change if considering the wider southern New England supply chain?

Subject Area 7	Where should MA and/or Southern New England supply chain be focusing effort/investment etc.
Rate in order of importance 1. Supply Chain Development - Ensuring supply chain are technically competent. 2. Local Incentives (i.e. tax relief, grants etc.) 3. Physical Asset and Improvement Plans (i.e. port infrastructure, jones act compliant vessels) 4. Workforce Training and Education (GWO certification for example) 5. Communicating the Available Supply Chain 6. Other (Suggestions)	
Subject Area 8	$/MWh additional on PPA to enhance local content
Would additional revenue, conditional on enhanced local content, incentivize contracting with local supply chain? If so, what approximate level of additional revenue support would be required?	

A.2 OEMs/Tier 1s

Subject Area 1	How do you define your Tier 2 packages?
What is (or could be) the scope of your OSW supply? What are the Tier 2 packages as defined by your organization for each of these scopes?	
Subject Area 2	How do you influence Tier 2/3 supply chain procurement?
How do you make Tier 2/3 suppliers aware of your requirements? What influence do you have in the selection of Tier 3 suppliers? Do you identify locations for the Tier 2/3 suppliers? Do you get support from developers in identifying capable local companies?	
Subject Area 3	Internal Criteria for Evaluating Suppliers
How would you describe your process for evaluating Tier 2 suppliers? Is part of the process looking at their supply chain network? How do you look to overcome the risks associated with sub-contacting new suppliers?	
Subject Area 4	Key challenges to obtaining high local content
Where do you expect local content to come from on your contracts? What are the barriers to you delivering supply locally? Are the local content requirements made clear to the Tier 2s?	
Subject Area 5	Supplier Engagement
What is your timeline for engagement with Tier 2 suppliers as part of bidding for contacts and award of sub-contracts? What is your process for engagement? How do you work to develop relationships with new suppliers?	
Subject Area 6	Understanding impact of PLAs on supply chain and local content metrics/KPIs
How are project labor agreements impacting the contracting of Tier 2 packages? Is the local supply chains understanding of skilled labor and unions a key influence in contracting success factors? Are you involved in the negotiations of PLAs?	

Subject Area 7	Strengths of Local Supply Chain
Rate each of the following in terms of strength of the MA supply chain (1 - Poor, 5 - Excellent): 1. Available skilled labor 2. Engineering and Environmental Services 3. Operations and Maintenance 4. Offshore Construction 5. Ports 6. Raw material supply (secondary steel) 7. Research and development 8. WTG and WTG component supply (inclusive of WTG towers) 9. Electrical infrastructure supply (onshore and offshore substation) 10. Cables (Export cables and Inter Array Cables, including ancillaries.) How would you rate the strength of the existing OSW supply chain eco-system in MA? (1 - Poor, 5 - Excellent) Why? Where do you believe MA ranks in comparison to neighboring states in regards to strength and depth of the OSW supply chain? 1. MA 2. RI 3. CT 4. NY 5. NJ How does your rating of these change if considering the wider southern New England supply chain?	
Subject area 8	Where should MA and/or Southern New England supply chain be focussing effort/investment etc.
Rate in order of importance 1. Supply Chain Development - Ensuring supply chain are technically competent. 2. Local Incentives (i.e tax relief, grants etc.) 3. Physical Asset and Improvement Plans (i.e port infrastructure, jones act compliant vessels) 4. Workforce Training and Education (GWO certification for example) 5. Communicating the Available Supply Chain 6. Other (Suggestions)	

APPENDIX B ADJACENT INDUSTRY ANALYSIS

To understand the scope and scale of some of the greatest opportunities for OSW industry growth, the research team identified "Adjacent Industries" that have similar workforce competencies, supply chains, and activities to current OSW firms.

Firms within the identified Adjacent Industries currently have little to no involvement in OSW activities; however, their work processes and workforce skill sets may allow them to transition into the OSW supply chain with relative ease. Identifying these industries highlights a potential economic sector that could easily support and grow with increased OSW demand.

Adjacent Industries include three distinct categories: Immediate Adjacent Manufacturing Industries; Secondary Adjacent Manufacturing Industries; and Support Industries.

- Immediate Adjacent Manufacturing Industries. This category includes the industries that share a federal industry classification code (six-digit NAICS) with OSW manufacturing companies. Transition to OSW-related work would be most rapid for companies in this category. Examples include Shipbuilding and Repairing, Motor and Generator Manufacturing, and Fabricated Structural Metal Manufacturing.

- Secondary Adjacent Manufacturing Industries. This category includes industries in the same general industry classifications (four-digit NAICS codes) but differs at the more granular level (six-digit NAICS codes). These industries conduct the same family of activities as OSW manufacturing firms, but their transition to OSW work would take more investment and time than Immediate Adjacent Manufacturing Industries. Examples include: Industrial Mold Manufacturing, Aircraft Engine and Engine Parts Manufacturing, and Guided Missile and Plate Work Manufacturing.

- Support Industries. This category includes industries that are upstream of Immediate Adjacent Manufacturing Industries. They are typically industries that involve raw materials extraction and manufacturing. Growth in the OSW market might require changes in operations, but since these companies tend to focus on raw materials and upstream components, those changes are likely to be minimal. Examples include: Copper Rolling, Drawing, Extruding, and Alloying; Plastics Material and Resin Manufacturing; and Machine Shops.

All Adjacent Industries were examined by available data in Q1 2020, prior to the onset of the global pandemic.

B.1 Immediate Adjacent Manufacturing Industries

Massachusetts had about 4,190 workers employed in Immediate Adjacent Manufacturing Industries (IAMI) across 167 establishments at the start of 2020. Middlesex County alone had 35 establishments employing 1,080 workers, while Worcester and Bristol Counties had 28 IAM establishments (1,330 workers) and 26 establishments (1,470 workers), respectively. Overall, the Commonwealth had lost 780 IAMI employees over the last five years.

The fourteen IAMI used in this report are listed in Table 1.

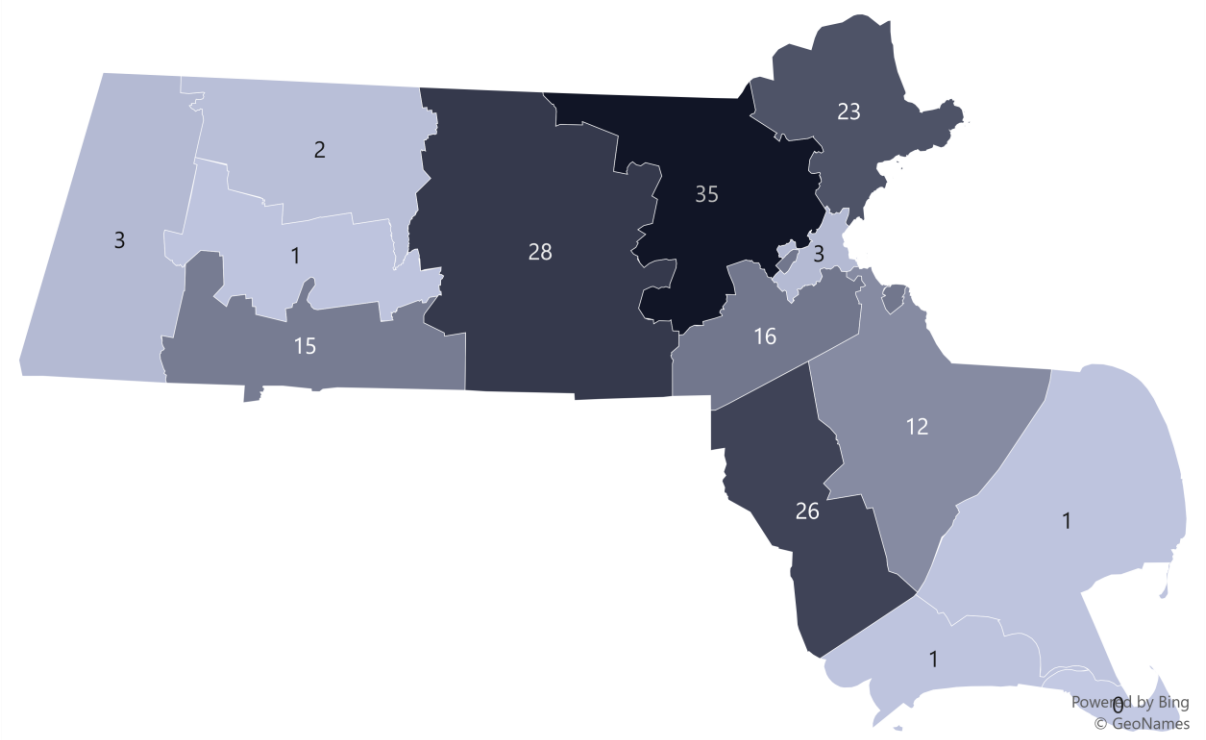


Figure B.1 - Immediate Adjacent Manufacturing Industry Establishments, Q1 2020

NAICS	Industry Name
336411	Aircraft Manufacturing
335921	Fiber Optic Cable Manufacturing
333611	Turbine and Turbine Generator Set Units Manufacturing
335311	Power, Distribution, and Specialty Transformer Manufacturing
335313	Switchgear and Switchboard Apparatus Manufacturing
335312	Motor and Generator Manufacturing
333921	Elevator and Moving Stairway Manufacturing
332911	Industrial Valve Manufacturing
314994	Rope, Cordage, Twine, Tire Cord, and Tire Fabric Mills
326122	Plastics Pipe and Pipe Fitting Manufacturing
331110	Iron and Steel Mills and Ferroalloy Manufacturing
332312	Fabricated Structural Metal Manufacturing
333517	Machine Tool Manufacturing
336611	Ship Building and Repairing

Table B.1 - OSW Immediate Adjacent Manufacturing Industries

B.2 Secondary Adjacent Manufacturing Industries

Massachusetts was home to 247,070 jobs in Secondary Adjacent Manufacturing Industries (SAMI) across 17,622 firms in 2020. About 70% of these jobs could be found in three counties: Middlesex County (90,090 jobs across 4,136 firms), Suffolk County (53,750 jobs; 2,315 firms), and Norfolk County (26,460 jobs; 1,829 firms). Worcester and Essex Counties also claimed home to over SAMI establishments (Error! Reference source not found.). Employment had stayed relatively s teady across the Commonwealth over the previous five years.

The twenty-six SAMI used in this report are listed in Table 2.

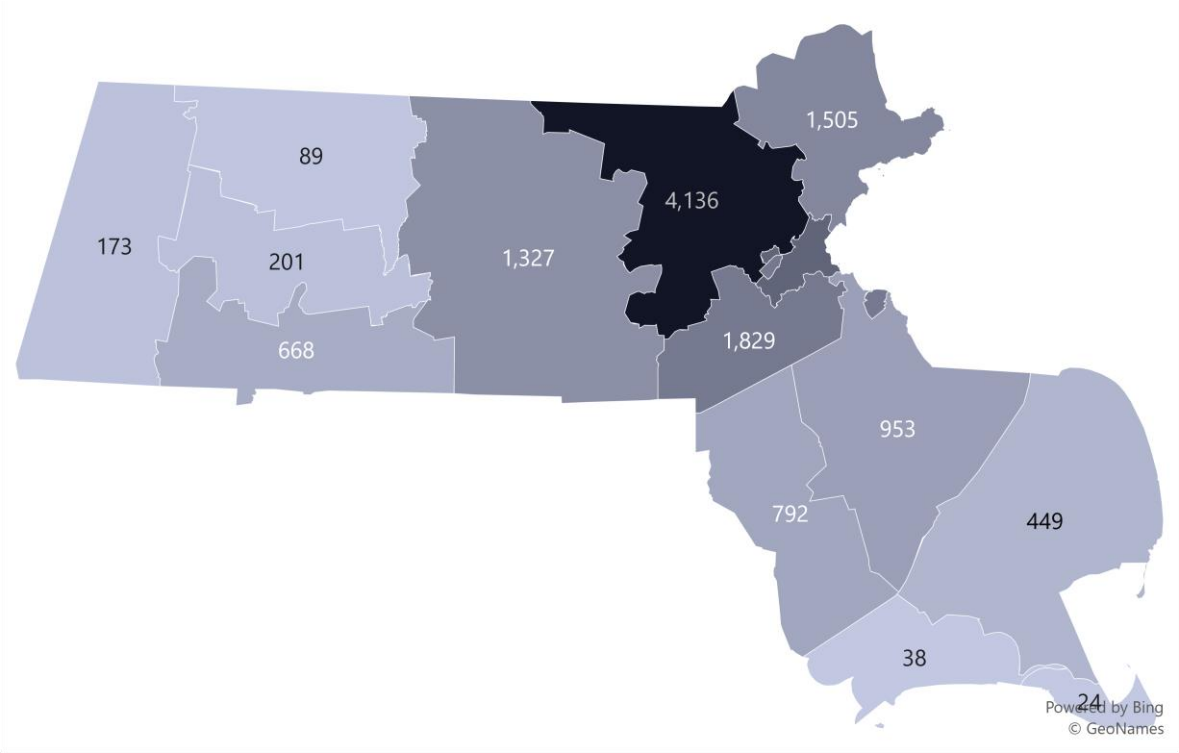


Figure B.2 - Secondary Adjacent Manufacturing Industry Establishments, Q1 2020

NAICS	Industry Name
314999	All Other Miscellaneous Textile Product Mills
326121	Unlaminated Plastics Profile Shape Manufacturing
332311	Prefabricated Metal Building and Component Manufacturing
332313	Plate Work Manufacturing
332912	Fluid Power Valve and Hose Fitting Manufacturing
332913	Plumbing Fixture Fitting and Trim Manufacturing
332919	Other Metal Valve and Pipe Fitting Manufacturing
333111	Farm Machinery and Equipment Manufacturing
333511	Industrial Mold Manufacturing
333514	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing
333515	Cutting Tool and Machine Tool Accessory Manufacturing
333519	Rolling Mill and Other Metalworking Machinery Manufacturing
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
333613	Mechanical Power Transmission Equipment Manufacturing
333618	Other Engine Equipment Manufacturing
333922	Conveyor and Conveying Equipment Manufacturing
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing
335314	Relay and Industrial Control Manufacturing
335929	Other Communication and Energy Wire Manufacturing
336412	Aircraft Engine and Engine Parts Manufacturing
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
336612	Boat Building

Figure B.3 - OSW Secondary Adjacent Manufacturing Industries

B.3 Support Industries

The Support Industries (SI) employed 18,980 workers across 305 Massachusetts' firms to start 2020. Worcester County had the most SI establishments (72 firms) of any county in the state, while Essex County had the largest SI workforce (8,490 workers). Middlesex, Hamden, and Bristol counties all employed over 1,000 SI workers as well, across 43, 39, and 35 establishments, respectively (Figure 14). The Commonwealth had lost 270 SI workers since 2015.

The twenty-two SI examined in this report include all those with over $3 million in annual in-state sales to the Immediate Adjacent Industries (Table 3).

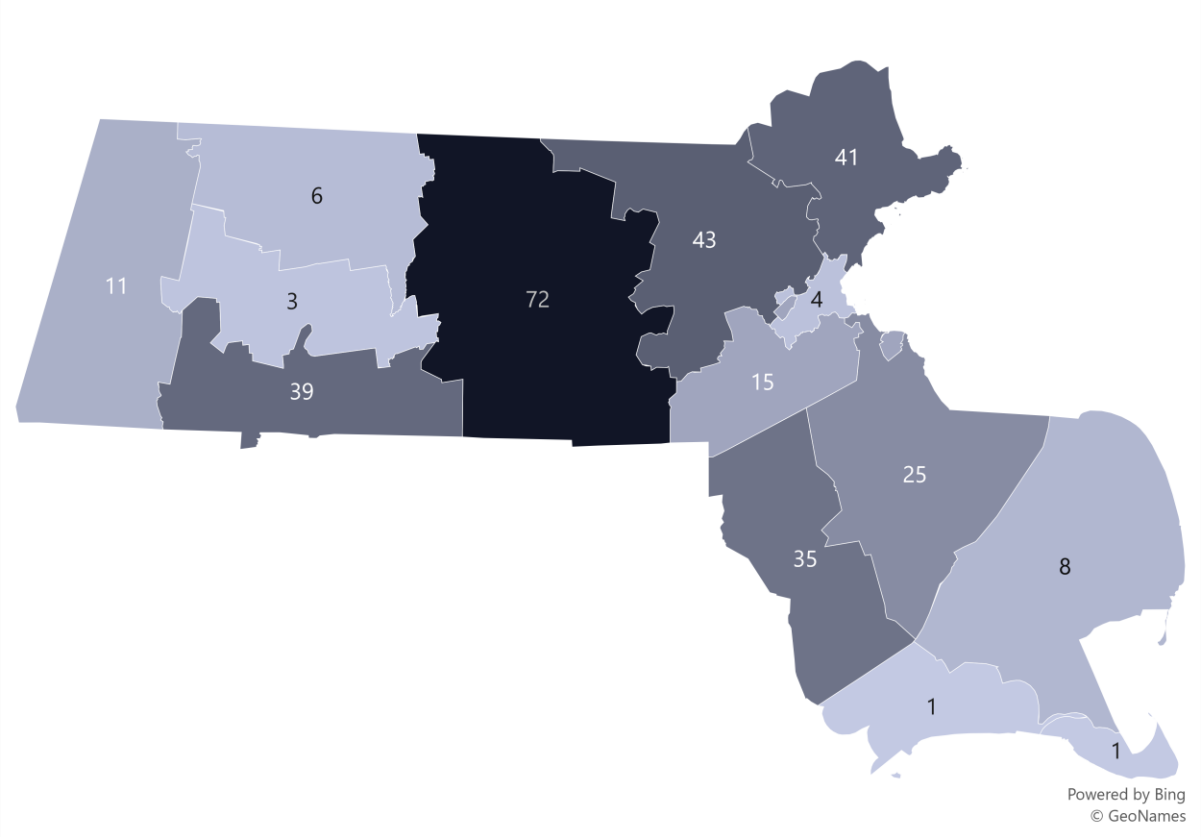


Figure B.4 - Support Industry Establishments, Q1 2020

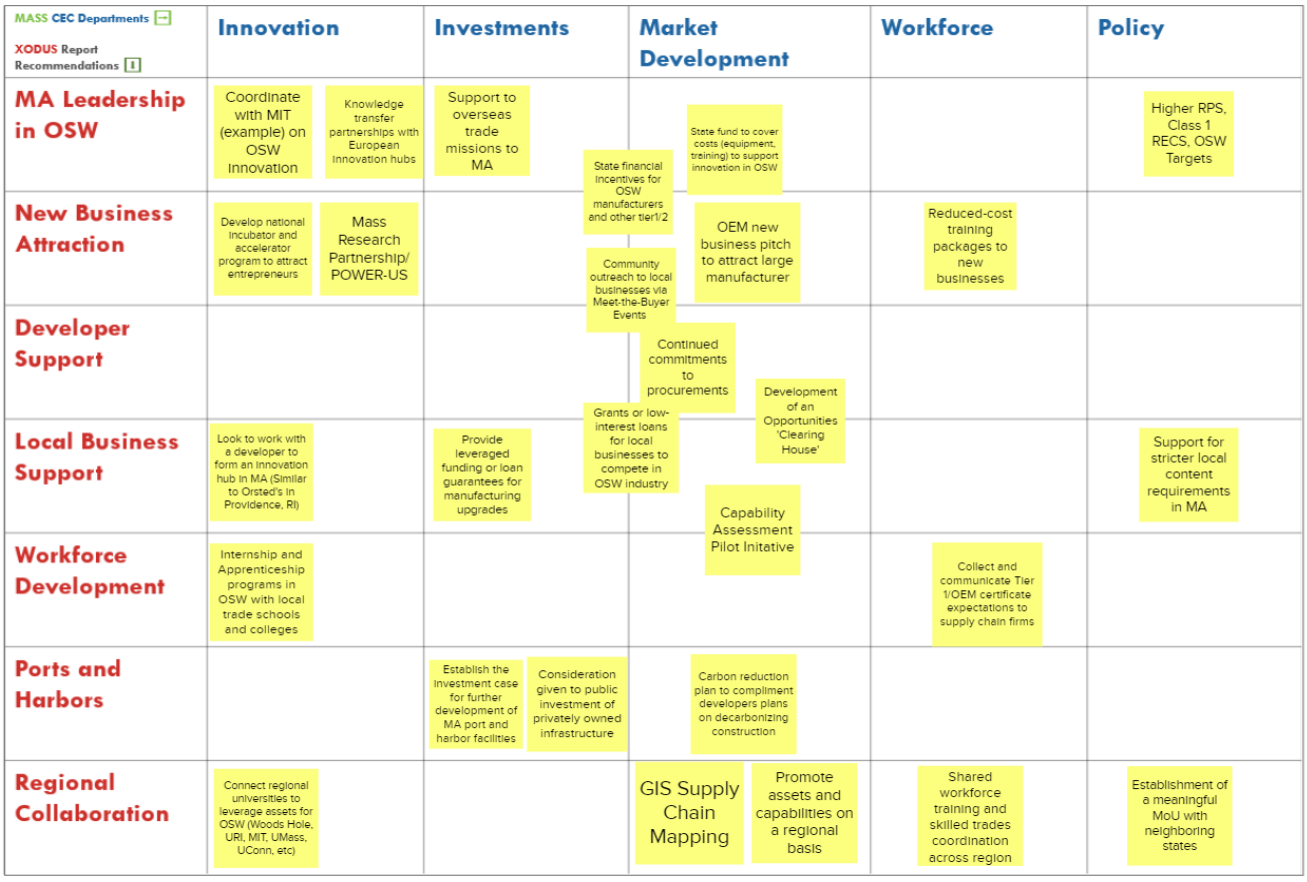
NAICS	Industry Name
314999	Copper Rolling, Drawing, Extruding, and Alloying

326121	Corporate, Subsidiary, and Regional Managing Offices
332311	Plastics Material and Resin Manufacturing
332313	Machine Shops
332912	Wholesale Trade Agents and Brokers
332913	Relay and Industrial Control Manufacturing
332919	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
333111	Computer Systems Design Services
333511	Data Processing, Hosting, and Related Services
333514	Engineering Services
333515	Semiconductor and Related Device Manufacturing
333519	Wired Telecommunications Carriers
333612	Nonferrous Metal (except Aluminum) Smelting and Refining
333613	Commercial Banking
333618	Iron and Steel Forging
333922	Offices of Lawyers
333923	Switchgear and Switchboard Apparatus Manufacturing
333924	Paint and Coating Manufacturing
335314	Turbine and Turbine Generator Set Units Manufacturing
335929	Natural Gas Distribution
336412	All Other Basic Organic Chemical Manufacturing
336413	Printed Circuit Assembly (Electronic Assembly) Manufacturing

Table B.2 - Massachusetts OSW Support Industries

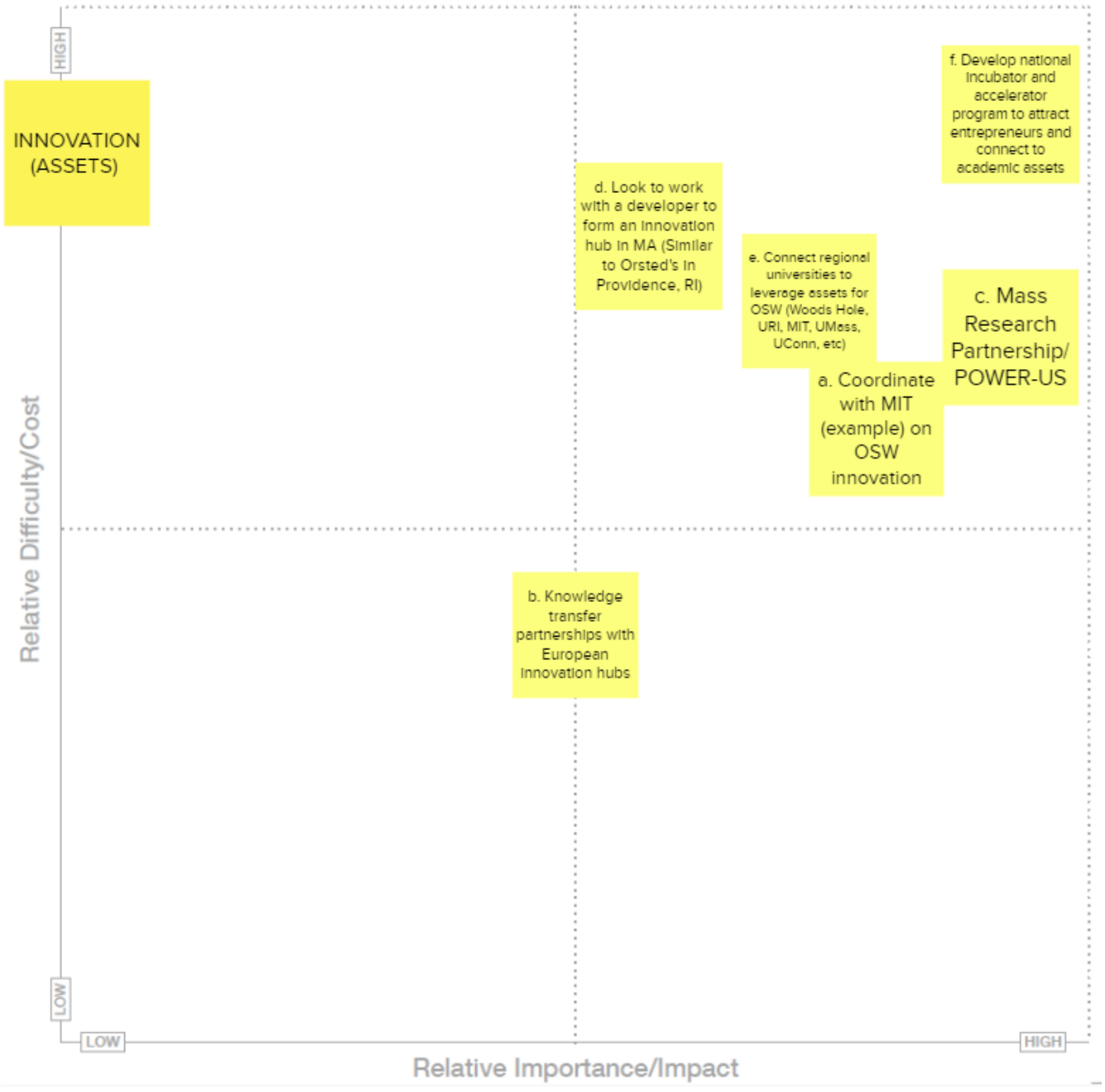
APPENDIX C RECOMMENDATION CATEGORIZATION

The outputs of the recommendation workshop session are detailed below:

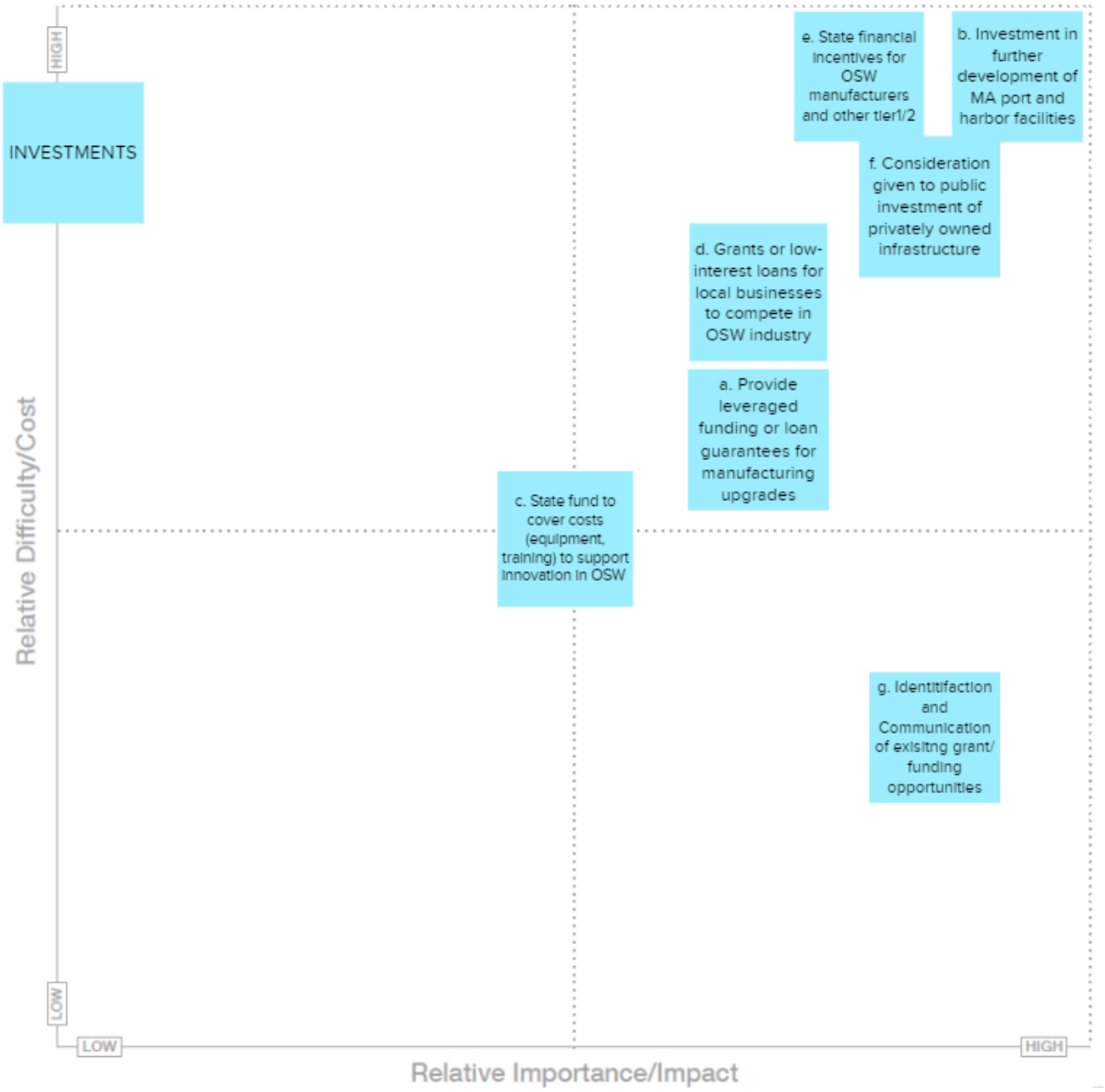


Recommendation Mapping Outputs

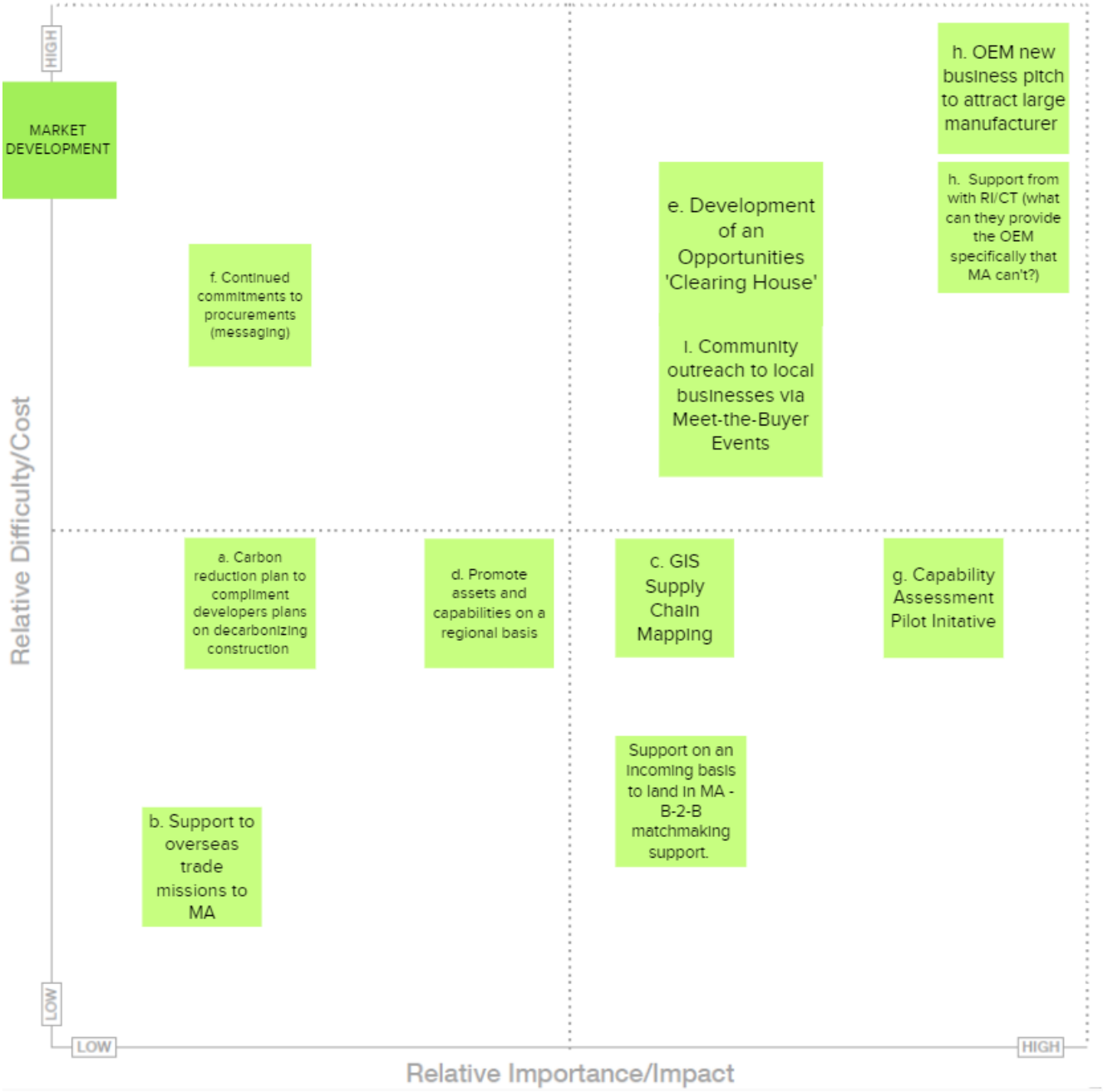
C.1 Innovation Recommendations



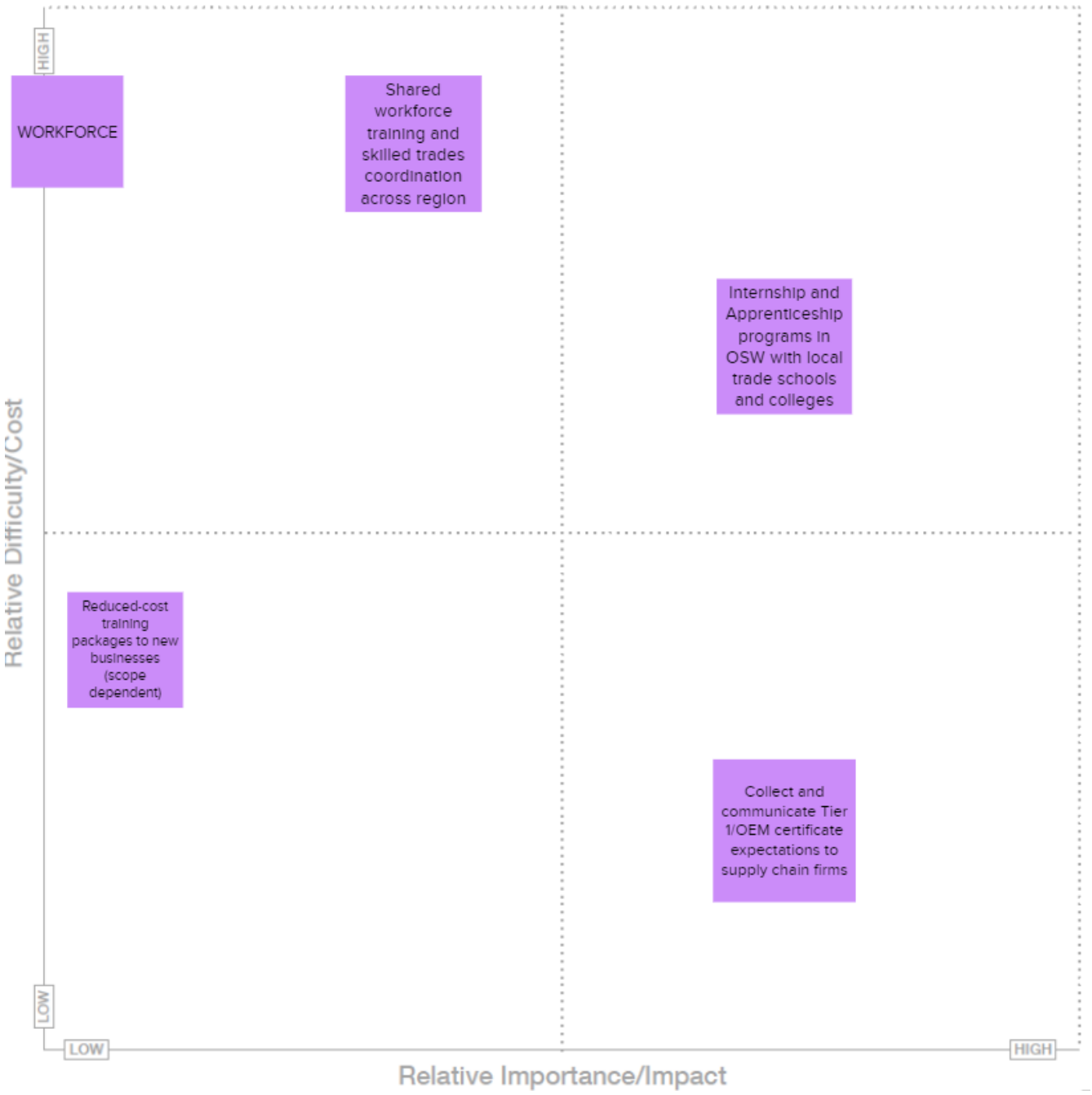
C.2 Investments Recommendations



C.3 Market Development Recommendations



C.4 Workforce Recommendations



C.5 Policy Recommendations