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Vietnam supply chain study

September 2021

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Executive Summary

Vietnam is an emerging offshore wind market and has an existing supply chain in industries with synergies to offshore wind, including oil and gas, and onshore wind, with the potential to also supply offshore wind.

Equinor and the Royal Norwegian Embassy in Hanoi have in cooperation with the Ministry of Industry and Trade (MOIT) in Vietnam outlined the scope of Supply Chain report. Equinor have commissioned BVG Associates (BVGA) and local partners Sterling Technical and Ngo Thi To Nhien to deliver a study of the Vietnamese offshore wind supply chain, which seeks to:

- Provide Equinor with an overview of the local supply chain in Vietnam
- Increase awareness of the opportunities offshore wind brings to Vietnamese suppliers
- Identify areas of the supply chain that require strategic development or strengthening, and
- Promote the Vietnamese supply chain.

Key areas of strong supply chain capability

- Development, project management and permitting - There are strong transferable capabilities and skills related to development and permitting from other sectors that Vietnamese suppliers can utilise in the offshore wind industry.
- Balance of plant - Vietnam has good capability from other industries in manufacturing of balance of plant, including foundations and cables. There are no significant gaps related to onshore infrastructure, where there is strong capability from other industries.
- Ports and infrastructure – Vietnam has a highly developed port infrastructure with sites suitable for both staging and fabrication of wind farm components.
- Operations, maintenance and servicing (OMS) - This is a logical area where Vietnam's existing oil and gas asset management supply chain, and the growing onshore wind supply chain, can diversify into offshore wind.
- Decommissioning - There is good transferable competence from other sectors in Vietnam to enable offshore wind decommissioning.

Supply chain areas where Vietnam should prioritise intervention

- Turbine foundation supply - Foundations are large items that do not need to interface with other supply chain elements until being installed on site. Local manufacture provides a further benefit in avoiding the costs and risks of transport. Vietnam has transferable skills and facilities in other industries. Combined, these factors make local foundation manufacture a logical supply chain element to establish in Vietnam.
- Turbine and foundation installation – Modest local content will naturally arise in the installation phase from vessel operations, use of port costs, fuel supply and waste disposal. There are two routes to securing significant additional local content during installation: building large installation vessels, and owning large installation vessels. Further local content can be captured by installation vessel mobilisation and demobilisation, sea fastener manufacturing, and crew provision.
- Blades – It is logical for large offshore wind markets to develop local blade manufacturing, given the costs and risks of transporting blades. The leading offshore turbine suppliers manufacture their own blades. Turbine suppliers need to be assured of a significant long-term market to invest in local blade manufacturing. A blade facility needs to be located close to a quayside as the blades are too large to be moved by road or rail. Vietnam does not have strong transferable skills or facilities from other industries, so significant development and investment will be required.
- Array and subsea export cables supply and installation – high-voltage subsea export cables tend to be rated at 220kV and offshore wind is becoming a dominant part of that market, so greater levels of production are needed. Cables are easily transported so local supply is not essential. Existing cable suppliers in Vietnam could expand their facilities to supply the offshore wind market, although they will face competition from other suppliers in Asia.
- Offshore substation (topside and foundation) - Substation topside fabrication and integration require similar capabilities to oil rig topsides or ship fabrication and fit out. Substation foundations are small in volumes compared to turbine foundations and fabrication require similar capabilities to large steel structure fabrication for oil rig foundation fabrication. Vietnam has several suppliers that could provide offshore substations that would benefit from focussed intervention to strengthen their capabilities.

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- Nacelle assembly - Accounting for up to 5% of the turbine value, nacelle assembly can be a way of localising at least some of the turbine value. Nacelle assembly can make sense in a market if the manufacture of some other nacelle components are located there too. Vietnam faces competition from other Asian countries in establishing nacelle assembly facilities. Turbine manufacturers will require visibility of a stable long-term market to consider investment in such facilities in Vietnam.

Key deliveries and gaps identified

The key supply chain gaps identified are:

- Development, project management and permitting - gaps in the supply chain include the experience of interpreting survey data related to offshore wind, including environmental data, metocean data and geotechnical data.
- Turbine - gaps in the Vietnamese supply chain related to turbines include manufacturing and assembly of nacelles, blades and electrical systems.
- Balance of plant - gaps in the supply chain related to foundations include handling larger foundation volumes and greater diameters. For cable manufacturing, gaps include facilities to manufacture higher voltage array cables, which would require suppliers to have confidence in the scale of the long-term market opportunity.
- Installation and commissioning - gaps related to the installation and commissioning of the wind farm are related to the lack of Vietnamese turbine foundation or offshore substation installation vessels, and the lack of experience and capability in cable laying.
- OMS - the key gap is technician competence related to offshore wind.
- Decommissioning - the key gap is related to cable decommissioning, but this is not likely to be relevant until the 2050s.

Key recommendations for Vietnam

- Agree a shared ambition for supply chain development with industry
- Promote Vietnamese supply chain, by engaging early with international suppliers and developers, and considering measures to increase competitiveness for Vietnamese suppliers
- Create offshore wind clusters of capability and competence
- Train workers to upskill workforce
- Seek to learn from international partners and contractors on early projects and from this develop local competence
- Demonstrate how experience from other sectors can transfer to offshore wind
- Partner with established suppliers, and encourage joint ventures in Vietnam with experienced suppliers
- Encourage buyers to be transparent about opportunities, by proactively engaging with local supply chain, and implement a supply chain data base and a supply chain portal to advertise opportunities to suppliers
- Target investment to the areas of greatest strategic need in the supply chain. These include turbine foundation supply and turbine and foundation installation as priorities.

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1. Introduction

Equinor is developing offshore wind projects globally. Vietnam is an emerging offshore wind market and is therefore a key country of interest to Equinor.

Vietnam has an existing supply chain in industries with synergies to offshore wind, including oil and gas, and onshore wind, with the potential to also supply offshore wind.

Equinor and the Royal Norwegian Embassy in Hanoi have in cooperation with the Ministry of Industry and Trade (MOIT) in Vietnam outlined the scope of Supply Chain report. Equinor have commissioned BVG Associates (BVGA) and local partners Sterling Technical and Ngo Thi To Nhien to deliver a study on the current and potential future Vietnamese offshore wind supply chain capability and workforce competence.

The purpose of the study is to:

- Provide Equinor with an overview of the local supply chain in Vietnam
- Increase awareness of the opportunities offshore wind brings to Vietnamese suppliers
- Identify areas of the supply chain that require strategic development or strengthening, and
- Promote the Vietnamese supply chain.

The World Bank Group (WBG) published the *Offshore wind roadmap for Vietnam*[1] in June 2021, where the supply chain and port infrastructure in Vietnam was assessed. This study builds on the work done in the roadmap, carrying out a deeper analysis of the current and potential future supply chain in Vietnam, and assessing how ports and other infrastructure might enable the supply chain to develop. Further, this study looks at the modelled number of FTEs created annually from offshore wind in Vietnam in eight different job categories.

The study identifies gaps and opportunities for the supply chain, port and other infrastructure, and in the workforce competency, as well as provides recommendations.

A database of suppliers was developed and delivered separately that captures the capability of the existing supply chain.

[1] *Offshore Wind Roadmap for Vietnam*, BVG Associates on behalf of The World Bank Group, June 2021, available online at https://documents.worldbank.org/en/publication/documents-reports/documentdetail/261981623120856300/offshore-wind-development-program-offshore-wind-roadmap-for-vietnam, last accessed July 2021.

2. Methodology

The work was carried out in six stages

1. Supplier engagement
2. Supply chain analysis
3. Port and other infrastructure assessment
4. Jobs analysis
5. Identification of gaps and opportunities, and
6. Recommendations

Supplier engagement

Supply chain categorisation

A supply chain categorisation broken down into 132 level 3 categories was agreed with Equinor and MOIT, and has been included in Appendix A.

Market scenarios

Two market scenarios were established for use in the study, which included intertidal, conventional fixed and floating offshore wind.

Low growth scenario

The low growth scenario reaches 5GW of installed capacity in 2030, and 11GW of installed capacity in 2035. Figure 1 shows the long-term growth in the low growth scenario

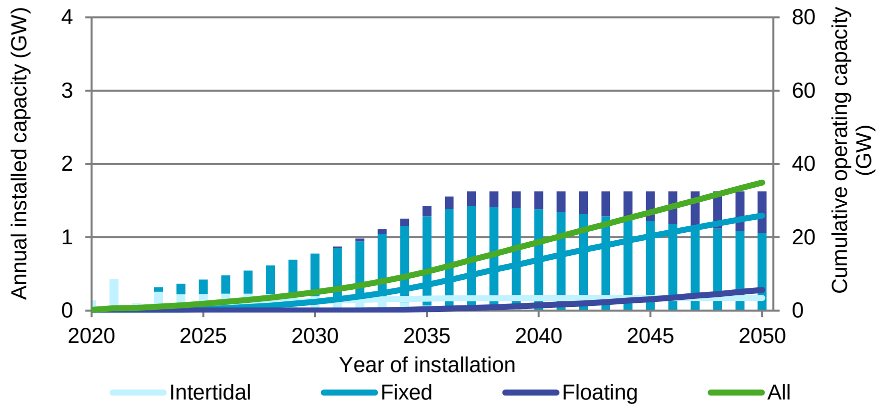

Figure 1 Low growth scenario

High growth scenario

The high growth scenario reaches 10GW of installed capacity in 2030, and 25GW of installed capacity in 2035. Figure 2 shows the long-term growth in the high growth scenario

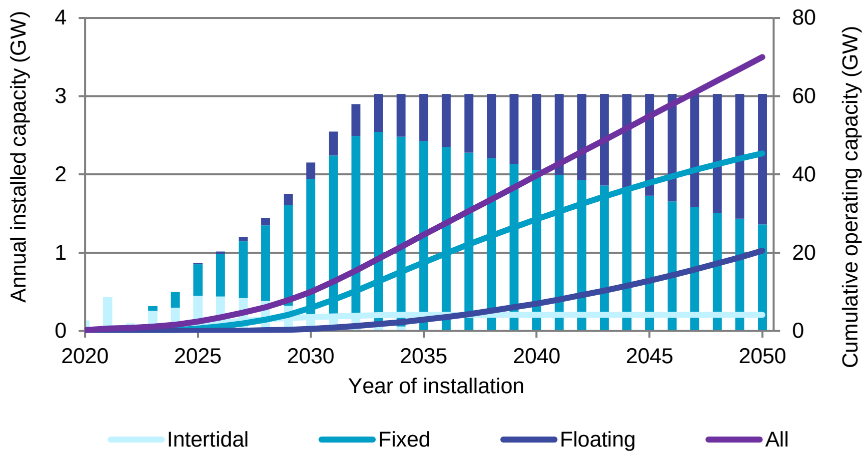

Figure 2 High growth scenario

Plan for supplier engagement

Desk research and team knowledge was used to identify a long list of companies in Vietnam that either currently supply to offshore wind, or that could potentially do so in the future, with the right investment, training and development.

Three categories of suppliers were established and an engagement strategy for each was developed, as shown in Table 1.

Table 1 Supplier categories and engagement strategy

Category	Definition	Engagement
Mid importance	One of many local suppliers in the supply chain category	Questionnaire sent by email
High importance	One of only a few local suppliers in the supply chain category	Questionnaire by email, and arranged a telephone interview to discuss further
Very high importance	One of only a few local suppliers in a supply chain category of strategic importance	Contacted directly to set up an extensive interview and gave them the opportunity to fill in the questionnaire

The supplier questionnaire was also shared on social media. The questionnaire is included as Appendix B. The study included engagement with suppliers that are not currently involved in offshore wind, so an introduction to offshore wind in Vietnam was shared along with the questionnaire, included as Appendix C, to raise awareness of the opportunities offshore wind might bring.

Supplier database

A secure hosted online database was developed to collect supplier data

An Excel export from the database was delivered separately from this report.

Supply chain analysis

Based on the information gathered in the supplier engagement, and through desk research, questionnaires and interviews, the supply chain analysis provided in the *Offshore wind roadmap for Vietnam*[2] was updated. The engagement findings were used to delve deeper into the supply chain and verify findings. The study assessed current suppliers to offshore wind and suppliers that could potentially supply to offshore wind in the future.

Port and other infrastructure assessment

A summary of the findings in the *Offshore wind roadmap for Vietnam*[3] was provided, and the assessment refreshed using new insights. The study also assessed where gaps in the infrastructure could hold back supply chain development, based on discussions with suppliers.

Jobs analysis

The total number of annual full time equivalent jobs (FTEs) created by offshore wind in Vietnam in the low and high scenario was calculated, and eight different categories of jobs that could be created in Vietnam from offshore wind were identified. Based on the IRENA study *Renewable energy benefits: leveraging local capacity for offshore wind*[4], the annual FTEs created from offshore wind in Vietnam in the high and low scenarios for each of these categories were then calculated. The categories modelled were:

1. Engineers
2. Factory and civil workers
3. Crane operators
4. Subject experts – environmental, legal, regulatory and financial
5. Logistics experts
6. Ship crew
7. Technicians, and
8. Site security and cleaning personnel.

The study used job numbers identified for each of the above categories in *Renewable energy benefits: leveraging local capacity for offshore wind*[5] for a 500MW offshore wind farm and extrapolated this to the capacity in the low and high market scenario for Vietnam.

The number of annual FTEs required in each job category in Vietnam until 2035 was calculated, and the forecast numbers were discussed and tested with the following skills organisations:

- Electric Power University
- Hanoi University of Science and Technology
- Water Resource University, and
- Ho Chi Minh University of Technology

Identification of gaps

Based on the engagement with suppliers, the supply chain analysis, the ports and infrastructure assessment and the jobs analysis, capabilities, gaps and opportunities for the supply chain and the workforce were identified.

Recommendations

Recommendations to MOIT and the offshore wind industry were provided based on the findings from the study and the capabilities, gaps and opportunities identified.

[2] *Offshore Wind Roadmap for Vietnam*, BVG Associates on behalf of The World Bank Group, June 2021, available online at https://documents.worldbank.org/en/publication/documents-reports/documentdetail/261981623120856300/offshore-wind-development-program-offshore-wind-roadmap-for-vietnam, last accessed July 2021.

[3] *As above*

[4] *Renewable energy benefits: leveraging local capacity for offshore wind,* IRENA, available online at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Leveraging_for_Offshore_Wind_2018.pdf, last accessed July 2021

[5] *As above*

3. Supplier engagement

Through desk research and engagement via social media, around 300 companies were identified that could supply to the offshore wind industry now or in the future, following investment, training and development.

The study group engaged with the companies to request feedback via questionnaires. Of the ~300 companies approached, around 64 companies filled in the questionnaire provided. The remaining suppliers were either unable to complete the questionnaire, or not interested in providing the information.

Most of the suppliers engaged with were in Hồ Chí Minh City, but there were also a large number of suppliers located in Hà Nội, Đà Nẵng, Vũng Tàu, Gia Lai, Hải Phòng and Khánh Hòa.

The companies that provided feedback through the questionnaire cover 111 of the level 3 supply chain categories. All the companies identified have been included in the database.

Table 2 provides an overview of the companies identified in each level 2 supply chain category.

Table 2 Number of companies identified in each supply chain category

Level 1 service category	Level 2 service category	Number of companies in category
Development and project management	Environmental	31
	Technical	46
Turbine	Nacelle	13
	Rotor	30
	Tower	26
Balance of plant	Array cables	4
	Cables other	4
	Export cables	2
	Foundations	21
	Offshore substations	20
	Onshore substations	11
	Other	58
	Cable installation	12

Level 1 service category	Level 2 service category	Number of companies in category
Installation and commissioning	Foundation installation	16
	Offshore substation installation	15
	Onshore transmission installation	12
	Other installation	30
	Turbine installation	10
Operations, maintenance and service	Operations, maintenance and service	64
Decommissioning	Decommissioning	10

This level of potential demonstrates that Vietnam has strong transferable capability from other industrial sectors.

The suppliers identified in each level 2 might supply the larger contracts, or the smaller components within the larger scope. For example, most of the companies identified in the nacelle category could potentially supply fasteners and small components, not the full nacelle.

4. Supply chain analysis

4.1. Development and permitting

Vietnam's first offshore wind farms are all nearshore projects, and predominantly use adapted onshore turbines. They have been developed by Vietnamese developers and have mainly used the local supply chain for survey and engineering studies. Vietnamese companies have provided similar services to other maritime sectors, such as shipping and oil and gas, and can carry out most of the surveys needed in offshore wind. The number of companies that are either active in this area of the supply chain, or who could potentially supply to it in the future, is shown in Figure 3.

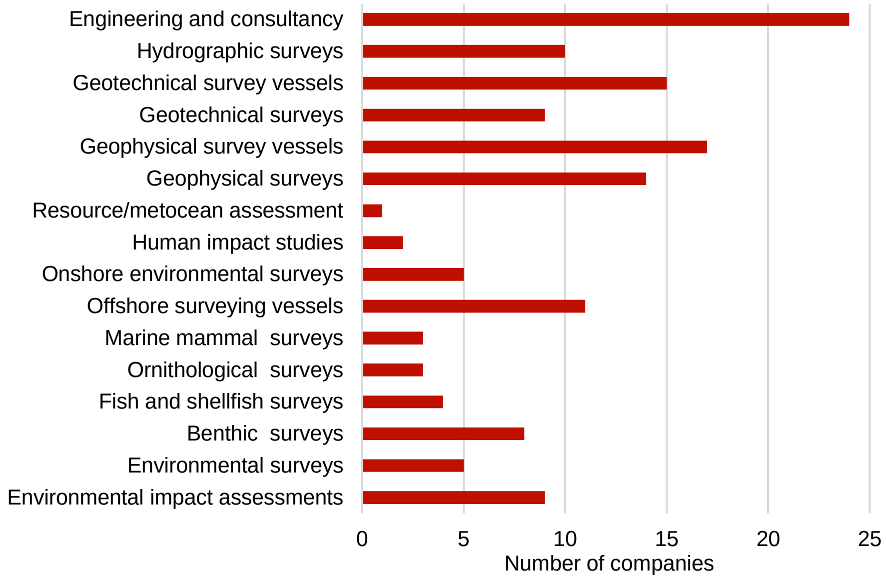

Figure 3 Number of current or potential future suppliers of development and permitting services in Vietnam.

Key suppliers we identified include Petrovietnam Technical Services Corporation (PTSC), Power Engineering Consulting Company (PECC), Tan Cang Offshore Services, Portcoast, Thien Nam Positioning, Vietnam Petroleum Institute (VPI) and Vietsovpetro JV.

Most companies providing survey and engineering services in Vietnam are privately owned, but larger public corporations, such as PECC, PTSC and VPI, also offer development services.

Most service providers have carried out these surveys and engineering studies for the oil and gas sector and have the potential to offer services in these areas. Several companies have started to supply these services to the offshore wind sector. For example, PTSC is reportedly undertaking early-stage surveys at the Ke Ga windfarm for Enterprize Energy and Tan Cang Offshore Services is working with local contractors to enter offshore wind.

The benefits to using the local supply chain during development are that these companies have a good knowledge of the environmental conditions, they understand relevant Vietnamese regulations and they can minimise logistics and labour costs.

Several Vietnamese companies can supply survey vessels. For example, NIRAS has previously used vessels supplied by VPI for environmental surveys. However, Vietnam does not have geotechnical survey vessels. Companies that have indicated that they can supply geotechnical survey vessels in Figure 3 are not currently capable and would need to invest in these vessels in the future. This presents an opportunity for international companies to fill the gap in the Vietnamese development supply chain. International vessel providers and crews are often preferred to ensure quality and meet international health and safety standards.

International suppliers are also favoured in areas of the supply chain where Vietnamese providers have little experience and can be undertaken remotely. Archaeological studies, navigational risk assessment and landscape studies, for example, involve data analysis rather than field work, and can be undertaken by experienced international suppliers. The development process can also be coordinated from outside Vietnam. This may change in the future as the market continues to grow and international developers localise their operations.

As the industry develops, global developers are likely to become increasingly involved, in many cases partnering with local developers. The development and permitting supply chain is likely to remain mostly Vietnamese, although global developers could use specialist engineering firms active in more established markets. Many of these firms will build a local presence. The barriers to entry are low, with investments mainly in skills to meet the needs of offshore wind. These conclusions are summarised in Figure 4.

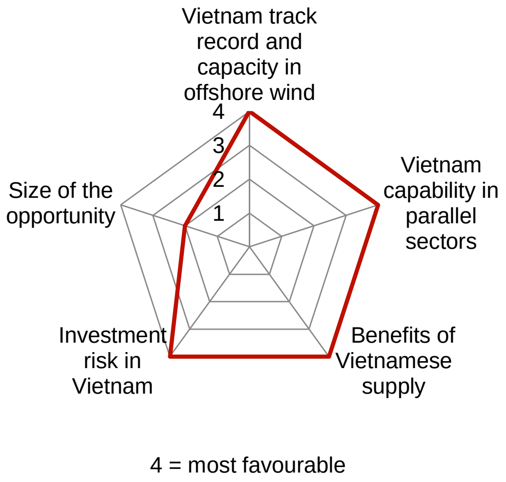

Figure 4 Assessment of supply chain for development and permitting.

4.2. Turbine

We anticipate that Vietnamese wind farms will use turbine suppliers that dominate the European, US and other Asian markets , since these are likely to offer the lowest cost of energy.

Nacelle, hub and assembly

Vietnam has no turbine manufacturing facilities for the supply and assembly of nacelles or hubs. The turbines for Vietnam's first offshore wind projects have been onshore products from global suppliers. Figure 5 shows a small number of companies capable of providing nacelle and hub components.

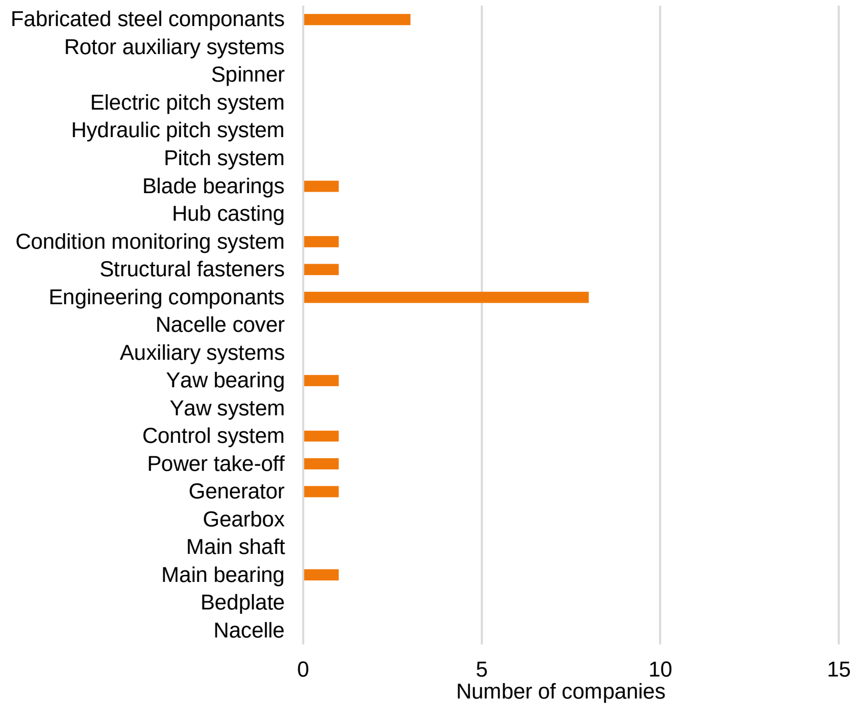

Figure 5 Number of current or potential future suppliers of nacelle and hub components in Vietnam

There are a small number of international suppliers that currently have manufacturing facilities in Vietnam. GE currently manufactures and exports wind turbine generators and electrical control systems from its factory in Haiphong. Thyssenkrupp is a German-based engineering firm that specialises in providing steel products to the automotive, construction and oil and gas industries. It also provides bearing components for offshore wind turbines. It has basic steel production facilities in Vietnam that could potentially supply bearing components for offshore wind turbines in the future with significant investment.

The opportunity for the Vietnamese supply chain is in the supply of less specialist nacelle and hub components which are used across sectors. Figure 5 shows several companies capable of providing small engineering components. This includes steel guards and flooring, cable and hose handling systems, drip trays, air ducts, lighting systems and small fasteners.

ABB is the only company with production facilities in Vietnam with the potential to provide generators for offshore turbines.

As east and southeast Asian markets develop, Europe-based turbine suppliers might see value in localising their activities. This will reduce transport costs, although decisions are likely to be driven by capacity constraints at existing factories. Local content requirements also bring forward decisions to localise. At the same time, suppliers are cautious, as their nacelles and hubs have complex supply chains and components that are critical to turbine performance and reliability. The barriers to investment are therefore high.

Political and market considerations have driven investment in nacelle assembly factories. Siemens Gamesa have a facility in Taiwan. GE is committed to a factory in Guangdong province in China. Vestas has committed to a factory in Japan. It is likely that in this decade, leading wind turbine suppliers will only establish one set of facilities in East and Southeast Asia. We do not expect this part of the supply chain to grow in Vietnam as new factories are expensive and there are no clear drivers to invest in Vietnam. These conclusions are summarised in Figure 6.

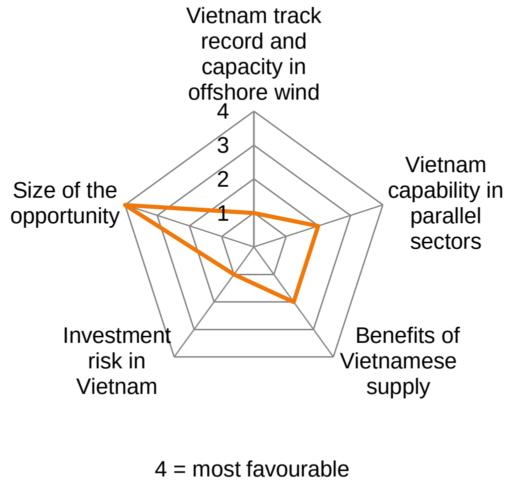

Figure 6 Assessment of supply chain for nacelle, hub and assembly.

Blades

Vietnam has no blade production facilities and the blades for Vietnam's offshore wind farms have been imported to date. The number of companies active in this area of the supply chain is shown in Figure 7.

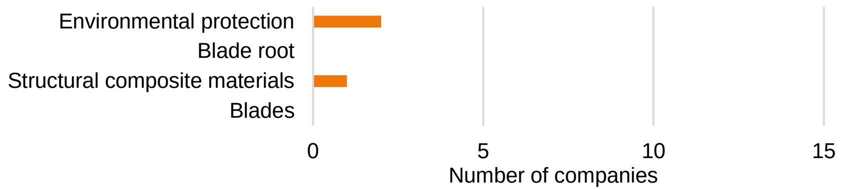

Figure 7 Number of current or potential future suppliers of blade components in Vietnam.

Vietnamese companies with the most potential to be part of the blade supply chain are Petrovietnam Coating and Triac Composites. Triac Composites provide composite materials such as resins and fibres. It could supply similar products to blade manufacturers, although we are not aware of any Vietnamese materials currently being used. In addition, Triac Composites could provide environmental protection for blades in the form of paints and gel. Petrovietnam Coating (PV Coating) also has the potential to supply environmental protection for blades in the future. It does not currently provide services to the offshore wind industry but has expressed an interest in entering the market. It is likely that other local suppliers in parallel sectors, such as shipbuilding and oil and gas, could transition to provide similar products.

The transport costs of blades are high, and manufacture is relatively easy to localise as its supply chain is mostly materials from commodity suppliers. The benefits of local supply of these commodities are much lower than for the finished blade.

Given the growing offshore wind market in the region, global turbine suppliers are likely to invest in east or southeast Asian manufacturing facilities. Vestas and Siemens Gamesa have made commitments to Taiwan.

Investment risks in a blade factory are high. A blade factory would cost approximately €150 million, assuming two blade moulds. There would need to be a strong pipeline of projects to support such an investment. These conclusions are summarised in Figure 8.

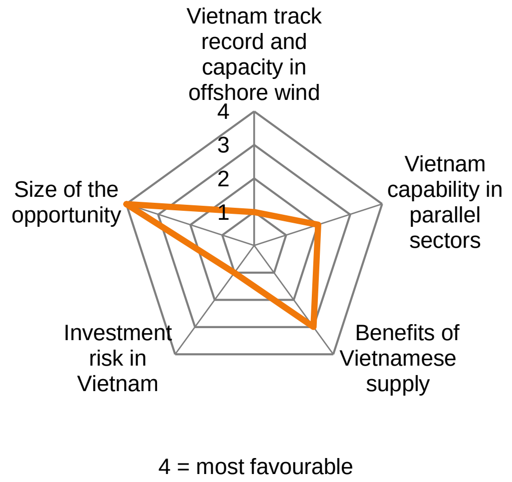

Figure 8 Assessment of supply chain for blades.

Towers

Vietnam has two manufacturing facilities capable of supplying turbine towers, with several companies able to provide smaller tower elements. Figure 9 shows the number of companies capable of providing tower components.

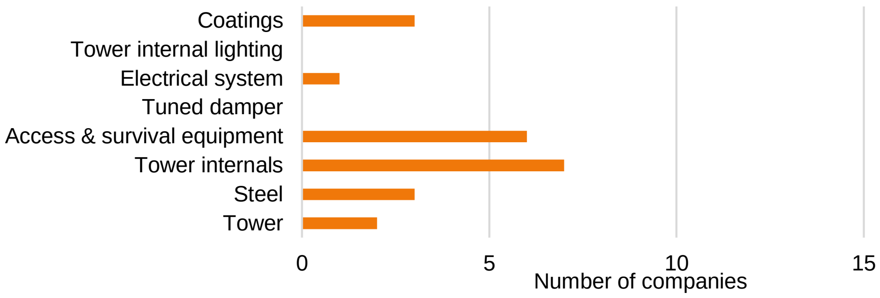

Figure 9 Number current or potential future suppliers of tower components in Vietnam.

CS Wind and SRE are the two companies capable of manufacturing turbine towers. Both companies have tower production facilities in the south of Vietnam and currently supply towers to the onshore wind market. With investment, they could supply offshore towers in the future. CS Wind, however, does not have direct access to quayside facilities which could be an issue for the load-out of larger offshore towers.

CS Wind and SRE both have coating facilities that could be used for offshore wind towers. PV Coating could provide coating services in the future. The company has experience in supplying coating services for oil and gas projects but has no offshore wind experience. It has plans to invest in an automatic blasting facility for turbine towers.

We identified several Vietnamese suppliers capable of providing steel for tower sections. Vietnam has an expanding steel-making industry and there are likely to be other suppliers that can provide steel for tower sections. We identified a large number of local providers that offer unworked steel products, such as bars, rods, and coils. While these products are not used to produce tower sections, they could be used in other parts of the supply chain.

We identified several suppliers capable of providing tower internals and personnel access systems. These suppliers provide elements such as ladders, grates, rails and electrical housing units which are widely used across other industries.

There is a logical business case for a coastal tower production facility in Vietnam or investment in existing facilities. There is a growing demand for offshore wind towers in Vietnam. The workforce is qualified to manage the largely automated production of towers. There are logistical benefits in local supply. Any new facility could export and supply Vietnam's wind market.

Investment risks in tower production facilities are high. A tower factory with a 1GW annual capacity would cost about €100 million. It would need at least two customers and turbine suppliers typically do not give long-term contracts to tower suppliers. Profit margins are typically small. These conclusions are summarised in Figure 10.

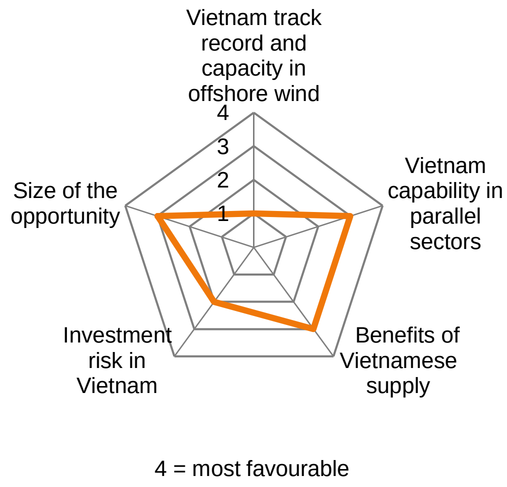

Figure 10 Assessment of supply chain for towers.

4.3. Balance of plant

Foundation supply

The foundations for Vietnam's intertidal wind farms have been concrete-capped piles. In the future, it is likely that the foundation market for fixed projects in Vietnam will be made up mainly of monopiles, with jackets in deeper waters.

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There may be opportunities for concrete gravity base foundations, and floating foundations will be used at the end of the decade in waters deeper than 50-60m.

The Vietnamese supply chain has considerable experience in steel fabrication, particularly from shipbuilding and oil and gas. This experience presents a significant opportunity for Vietnamese companies in foundation fabrication. Figure 11 shows the number of companies capable of providing foundation components.

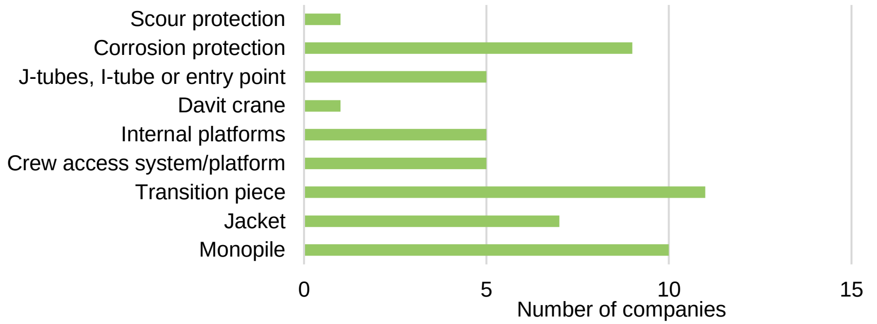

Figure 11 Number of current or potential future suppliers of foundation components in Vietnam.

Key suppliers include Alpha ECC, PetroVietnam Marine Shipyard , PetroVietnam Mechanical and Construction, PTSC, SRE and Vietsovpetro. These suppliers have experience of manufacturing steelwork for oil and gas platforms and have indicated that they can supply monopiles, jackets and transition pieces to the Vietnamese market. Currently their manufacturing capability is for smaller volumes and diameters of steel. Multiple companies report looking at investing in steel rolling equipment to manufacture structures with a larger diameter. Even established steel fabrication facilities will require investment to enable the high volume and lean manufacturing needed for offshore wind. These companies have indicated that they would look to export foundations to other Asian countries in the medium term and Europe longer term. CS Wind is also considering investing in a foundation factory, with a decision expected in 2021.

There are logistical benefits in the local supply of foundations. Vietnam has a large and experienced workforce of engineers. Labour costs lower than in Europe also make foundation production in Vietnam attractive. This is particularly relevant to jacket production which is labour intensive and has high transport costs.

Investment risks are high because of uneven demand and uncertainty over the foundation technology that will be adopted by the industry. These conclusions are summarised in Figure 12.

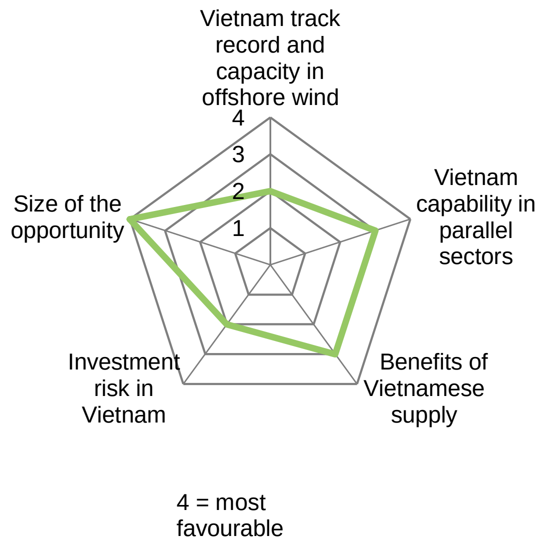

Figure 12 Assessment of supply chain for foundations.

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Array and export cable supply

Vietnam has no subsea cable production capability and it imports all its subsea cables for offshore wind. The number of companies active in this area of the supply chain is shown in Figure 13.

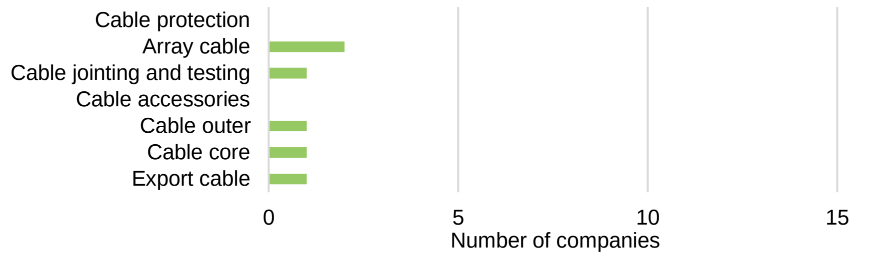


Figure 13 Number of current or potential future suppliers of array or export cable components in Vietnam.

LS Cable and System is the only major wind cable manufacturer currently present in Vietnam. It currently has two factories in the country. These factories do not currently manufacture subsea cable products although production could be expanded to supply array and export cables with further investment.

In addition, the state-owned enterprise Vietnam Electric Cable Corporation also known as CADIVI has the potential to supply array cables. The company currently produces medium voltage armoured onshore cable up to 36kV. With the deployment of larger turbines, array cables are now typically rated at 66kV. CADAVI would need to make an investment in order to provide array cables to the offshore wind market.

The logistical benefits of supply of export and array cabling from Vietnam are low because in many cases a single cable vessel can transport all the cable for a project from the factory in one or two journeys. Subsea cable factories in China, Japan and Korea are likely to be used for Vietnamese projects.

As the east and southeast Asian market grows, new investment is likely to be necessary, but cable suppliers typically seek to expand existing facilities rather than invest at new sites. This is because long lead times for new factories with low market certainty mean a significant investment risk. Suppliers are also cautious about diluting their technical competency at their centres of excellence.

The growth of the industry from intertidal projects to locations further from shore could drive interest in establishing HV cable and equipment capabilities. Whether Vietnam is chosen for a new factory would depend on the growth of the Vietnamese market compared to other countries, the visibility of future projects and the regional strategy of the supplier. These conclusions are summarised in Figure 14.

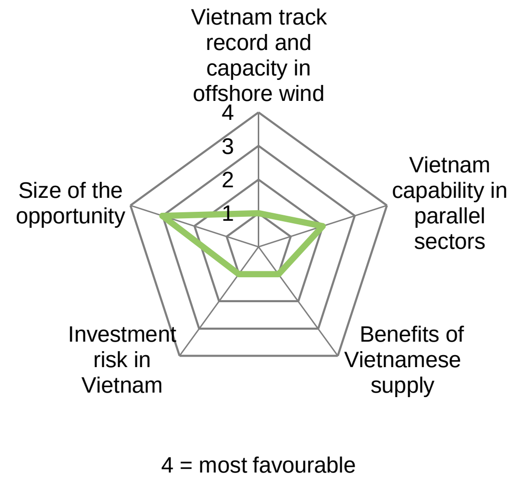


Figure 14 Assessment of supply chain for array and export cables.

Offshore substation supply

To date, intertidal offshore wind farms in Vietnam have been built without an offshore substation. Future wind farms will be located further from shore and will require one or more offshore substations.

Offshore substation supply has synergies with shipbuilding and the construction of oil and gas platforms. This is because it requires steel fabrication and systems integration skills. Vietnam has experience in these parallel sectors and there are several fabricators capable of supplying offshore substations. This is shown in Figure 15.

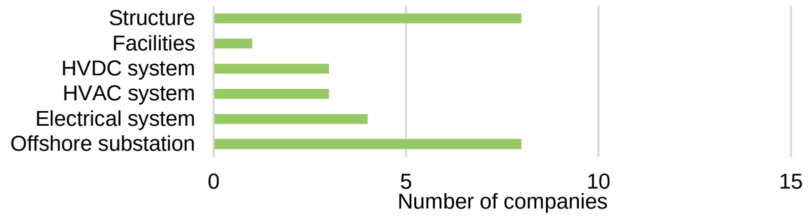


Figure 15 Number of current or potential future suppliers of offshore substation components in Vietnam.

Key offshore substation fabricators include Alpha ECC, DOOSAN, PetroVietnam Marine Shipyard, PetroVietnam Mechanical and Construction, PetroVietnam Metal Structures, PTSC, Slåttland Vietnam, and Vietsovpetro. These suppliers currently have the skills and experience to fabricate the steel structure.

Vietnam has the capability to supply electrical equipment. ABB has a transformer factory in Hanoi, and high voltage and medium voltage power product factories in Bac Ninh. Local suppliers, such as Dong Anh Electric Equipment Manufacturing Company and Thu Duc Electro-Mechanical Company, can provide transformers but not at the capacity needed for offshore substations. Further investment is needed to produce transformers with a greater capacity. The offshore wind industry, however, is typically too small to drive electrical equipment manufacturing investments. The power transmission and distribution sector is significantly larger and uses similar products. Its rapid growth in Vietnam could enable more investment.

Substations are typically one-off designs and therefore new entrants do not need to make investments to enable efficient volume production. Current suppliers in other markets typically work from existing sites because of the uneven demand and the fact that little specific investment is needed. International engineering firms take on EPCI contracts for substation supply and partner with Vietnamese companies capable of fabricating the topside. A challenge for new entrants has been the lower profit margins in offshore wind, relative to oil and gas. Figure 16 summarises our conclusions.

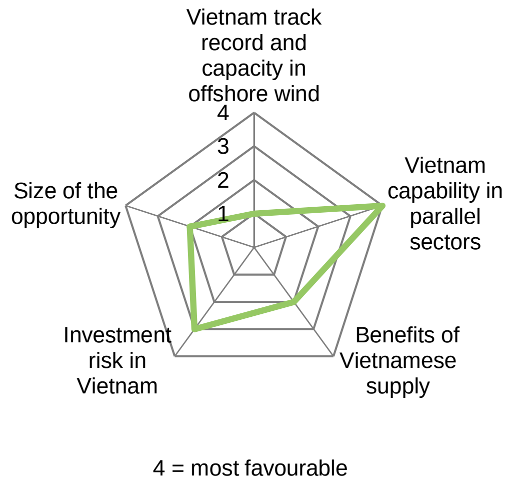


Figure 16 Assessment of supply chain for offshore substations.

Onshore infrastructure

Onshore infrastructure includes the onshore substation and the operations base. There are significant synergies with the rest of the civil engineering sector and this work is invariably provided by domestic companies. Figure 17 shows the number of civil engineering firms capable of constructing the onshore substation.

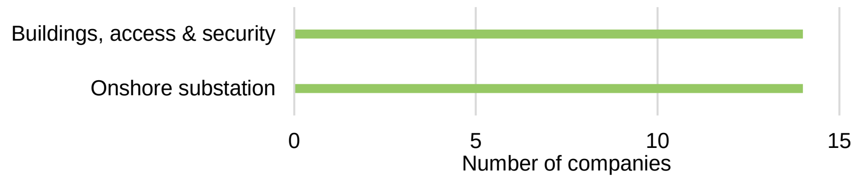
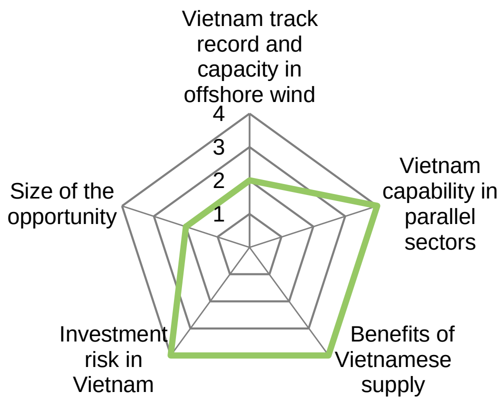


Figure 17 Number of current or potential future suppliers of onshore substation components in Vietnam.

Key suppliers include FECON, IPC Steel Structure , Khang Duc Construction & Investment, Power Construction Company, Power Plus Vietnam, PECC1, PECC2 and PTSC. These companies provide services to Vietnamese projects.

Ownership of these companies is split across the public and private sector. This is not an exhaustive list. There are likely to be many Vietnamese companies capable of carrying out the civil engineering work needed for the onshore export cable route, the onshore substation and the operations base. No significant investment by Vietnamese companies is likely to be necessary. Figure 18 summarises our conclusions.



4 = most favourable

Figure 18 Assessment of supply chain for onshore infrastructure.

4.4. Installation and commissioning

Turbine and foundation installation

Conventional fixed offshore wind farm foundations are installed by a jack-up vessel (which may also be used for turbines) or a floating heavy lift vessel. These vessels are built almost exclusively for offshore wind use. While Vietnam has floating construction vessels with cranes, these do not currently have the lifting capacity (at least to 1,500t) needed for offshore wind installations.

Vietnam has oil and gas, and shipping, companies with significant experience working offshore. If these contractors invest in suitable installation vessels, they could enter the market. Figure 19 shows the number of companies that could potentially supply installation vessels, equipment, and services with investment.

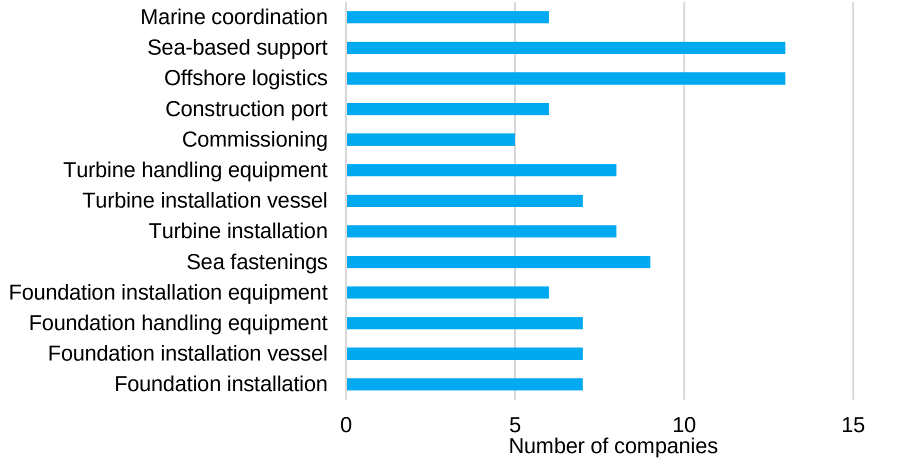


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Figure 19 Number of current or potential future suppliers of turbine and foundation installation services in Vietnam.

Key potential suppliers include Huy Hoang Logistic & Transportation, Khang Duc Construction & Investment, Offshore Energy Installation (OEI), PTSC Offshore Service, PTSC, and Vietsovpetro. These companies have the skills and equipment to carry out offshore installation operations but lack suitable installation vessels.

European installation contractors, such as DEME Group and Jan de Nul, currently supply jack-up up vessels and install turbines and foundation in Vietnam. This helps meet the requirements of contractors and lenders and reduces insurance costs.

Vietnam has a good supply chain to support installation operations. There are several companies that can offer ancillary vessels, such as crew transfer vessels, barges and ROV handling vessels, to provide sea-based support. This includes transferring crew to the wind farm for installation and commissioning tasks, transporting heavy components and other specialists functions such as launching, piloting and recovering ROVs. These are typically smaller local companies with Vietnamese crews. A challenge is that the principal installation contractors will require Vietnamese subcontractors to meet their health and safety standards, which may require additional training. Offshore logistical support can also be provided by several Vietnamese companies. It important to note that there are many companies that offer general freight forwarding in Vietnam. Companies that provide project logistics, such as Deugro, Meridian Shipping Service and Vietnam Projects Transport, are more suited to coordinating offshore wind installation operations.

For this part of the Vietnamese supply chain to develop, contractors must invest in suitable installation vessels and meet international health and safety standards. The offshore wind industry has seen a significant number of new vessels built, which suggests low barriers to investment. Joint ventures with established European contractors would reduce investment risk.

Offshore wind installation vessels are costly. The challenge has been balancing the capital cost of the vessel while ensuring that it continues to be capable of installing the ever-increasing size of turbines and foundations. Figure 20 summarises our conclusions.

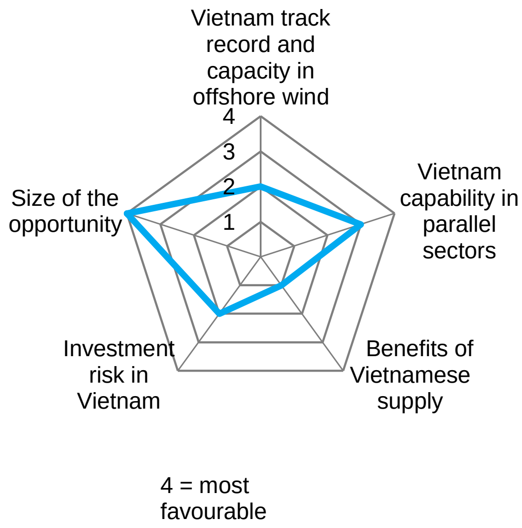

Figure 20 Assessment of supply chain for turbine and foundation installation.

Array and export cable installation

The techniques for laying cables for intertidal projects have similarities with the onshore export cable laying process for conventional offshore wind farms. Other than this the expertise and equipment for offshore projects is distinct. Array and export cable installation can in theory use the same vessels and equipment, but optimal solutions differ. Array cable laying vessels need to be manoeuvrable but do not need high carrying capacity. Export cable laying vessels are typically larger to carry the full length of an export cable and ideally can operate in shallow water. Vietnam has some cable laying vessels and equipment, but it is likely that suppliers will need to invest to compete with international contractors. The number of companies active in this area of the supply chain is shown in Figure 21.

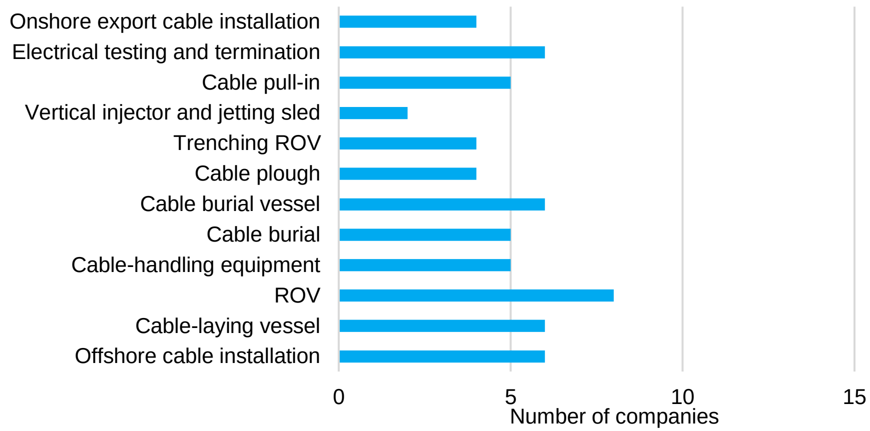

Figure 21 Number of current or potential future suppliers of cable installation services in Vietnam.

Key potential Vietnamese offshore cable installation contractors include OEI, PTSC , Tan Cang Offshore Services, Thien Nam Offshore Services and Vietsovpetro. All these offshore contractors have access to cable laying vessels. The vessels and equipment they have access to are however not at the standard of their international competitors which has offices in Vietnam. Vietnamese contractors have the potential to supply cable installation services in the future but will need to invest in vessels and equipment to be competitive in their domestic offshore wind market.

To our knowledge, none of these contractors have experience in supplying cable installation services to conventional offshore wind projects. A joint venture between PTSC and Vietsovpetro however secured the balance of plant EPCI contract for the Thang Long project in 2020. This included the installation scope for subsea cables; however, it is possible that the cable installation will be subcontracted to an international contractor.

Offshore wind cable laying is technically challenging, particularly the process of pulling in and terminating the cable at the base of the turbine. There are also significant risks in entering the market. As well as the investment in vessels and equipment, inexperienced cable-laying companies have suffered project delays in established offshore wind markets and the financial consequences can be severe. Partnering with an established contractor could lower the risk related to the impact of project delays.

The onshore export cable installation can be carried out by various civil engineering and construction companies. We identified FECON, Khang Duc Construction. Lilama 7 and Lilama 69-1 as suppliers currently capable of installing onshore export cables. It is likely that there are other Vietnamese companies in the construction sector that can undertake this work as well.

Figure 22 summarises our conclusions. We have updated the analysis to reflect the finding that Vietnam suppliers have less experience in offshore wind cable installation than original stated in the *Offshore wind roadmap for Vietnam*[6] supply chain analysis.

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[6] *Offshore Wind Roadmap for Vietnam*, BVG Associates on behalf of The World Bank Group, June 2021, available online at https://documents.worldbank.org/en/publication/documents-reports/documentdetail/261981623120856300/offshore-wind-development-program-offshore-wind-roadmap-for-vietnam, last accessed July 2021.

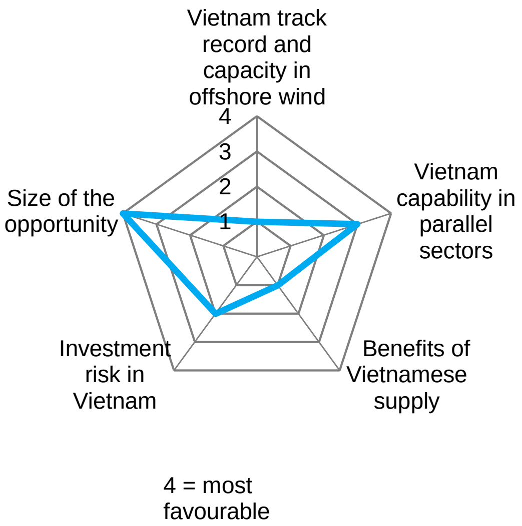

Figure 22 Assessment of supply chain for array and export cable installation.

Offshore substation installation

Offshore substation installation includes the foundation (usually a jacket) installation and the substation platform installation. Figure 23 shows the number of companies that could potentially supply installation vessels and services.

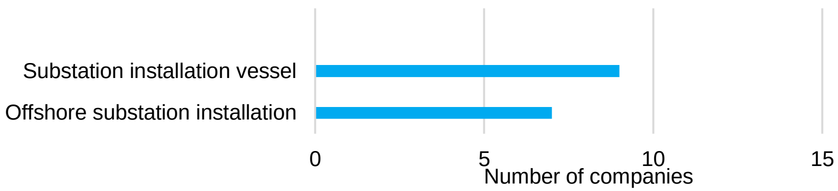

Figure 23 Number of current or potential future suppliers of onshore and offshore substation installation services in Vietnam.

The substation foundation is typically installed in the same way as a turbine foundation. It uses similar vessels and can be delivered as part of the turbine foundation installation contract. The same suppliers as for turbine foundations can therefore be used to install the substation foundations.

The substation platform is likely to weigh more than 2,000t. In most cases it is transported to site by barge. There are several Vietnamese installation contractors that can supply these barges, such as OEI, PTSC and Tan Cang Offshore Services. The substation is lifted into position by a heavy lift vessel once at the site. These vessels are typically 'borrowed' for short-term use from the oil and gas fleet, but none are currently operated by Vietnamese companies. The number of substation installation vessel suppliers in Figure 23 is made up of suppliers currently capable of supplying flat top barges to transport substations. These suppliers would need to make large investments to supply heavy lift vessels capable of installing substations.

4.5. Operations, maintenance and service

Wind farm operation

Wind farm operation combines some of the asset management expertise in onshore wind along with offshore logistics. The number of companies active in this area of the supply chain is shown in Figure 24.

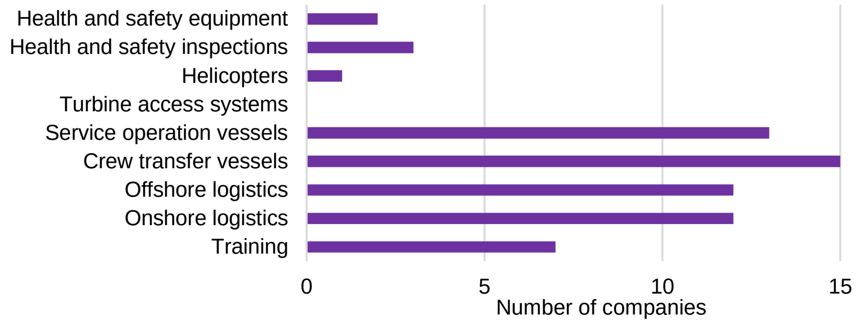

Figure 24 Number of current or potential future suppliers of wind farm operation services in Vietnam.

Vietnam has a growing onshore wind industry and therefore has relevant asset management skills.

Vietnam has a well-established oil and gas and shipping industry. It has a significant number of companies that can offer offshore logistics services. Key providers include Cuchi Shipping, Meridian Shipping Service, Petrosetco and Vietnam Projects Transport. These companies all have experience of managing logistics for oil and gas project and are currently capable of coordinating marine based activities and operations for offshore wind projects. These providers also provide onshore logistics services.

The country's shipbuilding industry also ensures a high number of shipyards capable of manufacturing crew transfer vessels (CTVs) and service operation vehicles (SOVs). The capability of these shipyards varies considerable owing to the site infrastructure and labour expertise.

The barriers to entry are generally low, revenue streams long-term and benefit of local supply high, which suggests potentially high competition in time.

Figure 25 summarises our conclusions.

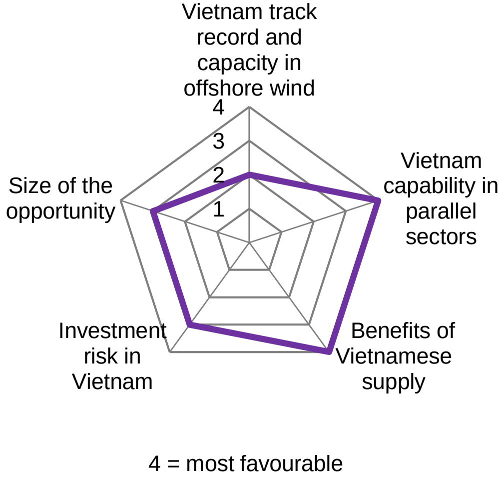

Figure 25 Assessment of supply chain for wind farm operation.

Turbine maintenance and service

Turbine maintenance and service is typically undertaken by the turbine supplier, generally under a service agreement of up to 15 years. A local workforce will be used for much of the work, and there is an opportunity for local companies offering inspection services and technicians during planned maintenance and unplanned service activities in response to turbine faults. Figure 26 shows the number of companies that could potentially supply turbine maintenance services.

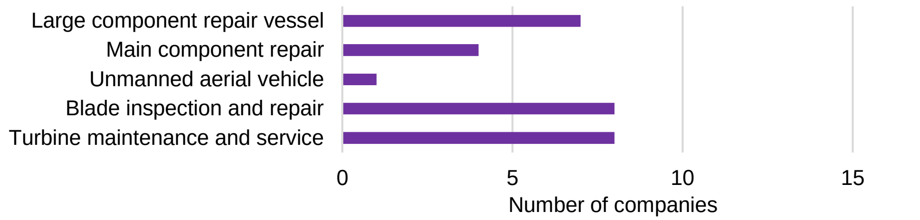

Figure 26 Number of current or potential future suppliers of turbine maintenance services in Vietnam.

GE Renewable Energy, Siemens Gamesa Renewable Energy and Vestas have regional offices in Vietnam and are currently capable of supplying turbine technicians to carry out maintenance work whilst the wind farms are covered under a service agreement. Blade inspection and repair is typically covered during this period. Blade inspection and repair is typically covered during this period. Alpha NDT was the only other company identified with the potential to provide blade inspection and repair services in the future.

Vietnamese suppliers, such as Alpha NDT, OEI, Petrovietnam Maintenance and Repair, PTSC and PTSC Production Services will potentially have access to large installation vessels in the future. These vessels are typically the same as those used for turbine installation. This would allow them to carry out main components refurbishment, replacement and repair if necessary.

The barriers to entry are low since investment will be mainly focused on ensuring a high-level skills base. Figure 27 summarises our conclusions.

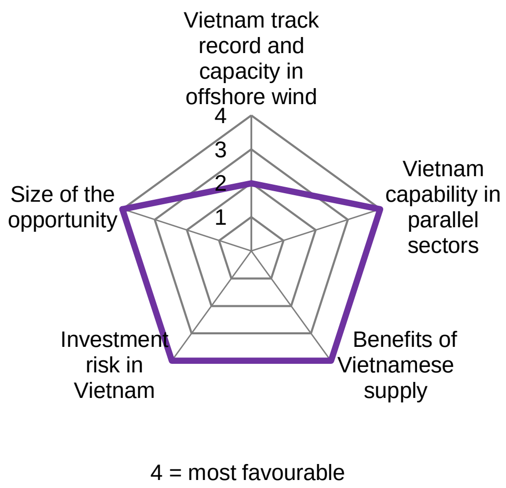

Figure 27 Assessment of supply chain for turbine maintenance and service.

Balance of plant maintenance and service

Balance of plant maintenance and service covers foundations, array and export cables and the substations. Cable maintenance and service is the most significant, with cable failures the biggest source of insurance claims in offshore wind, typically due to mechanical damage caused to the cables. It uses similar equipment to cable installation as array cables are often replaced rather than repaired, and the same companies could undertake the work.

Foundation maintenance and service includes inspections for corrosion or structural defects above and below the water line, and cleaning and repairing areas above the water line.

Substation maintenance and service primarily consists of non-intrusive inspections of topside switchgear and transformers, sampling of transformer oil, foundation and topside structural inspection and resulting infrequent service interventions. The number of companies active in this area of the supply chain is shown in Figure 28.

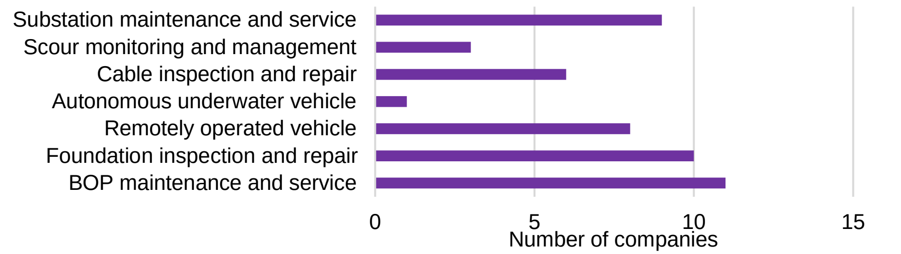

Figure 28 Number of current or potential future suppliers of balance of plant maintenance services in Vietnam.

The same Vietnamese contractors could be used for cable inspection and repair as are used for cable installation. As noted, these contractors are not currently able to carry out cable installation operations and are therefore unable to provide cable inspection and repair services. They have the potential to offer these services in the future with investment in vessels and cabling equipment.

Foundation inspection and repair typically does not require large vessels and installation contractors are not the sole provider of these services. This area of the supply chain is well covered by Vietnamese suppliers that have provided similar services for the foundations used to support oil and gas platforms. Key suppliers include Alpha NDT, Lam Hong Diving, Petrovietnam Maintenance and Repair Corporation, Tan Cang Offshore Services, Thien Nam Offshore Services, and Vietsovpetro . These companies are currently capable of supplying these services to offshore wind projects.

Substation maintenance and service may be undertaken by the electrical system supplier or subsidiaries of Electricity Vietnam, but it is likely that companies offering operational support to oil and gas platforms could undertake this work as well. This includes suppliers such as Alpha ECC, Petrovietnam Maintenance and Repair Corporation, PTSC Offshore Services, and Vietsovpetro. It is anticipated that the expertise of these service providers is more suited to the inspection and servicing of the substation structure. Maintenance work relating to the substation electrical system is likely to be better suited to specialist high voltage electrical contractors. ABB and Thu Duc Electro-Mechanical both currently offer these services.

The barriers to entry are relatively low. Cable inspection and repair requires access to suitable vessels and equipment which can be costly. Foundation inspection and repair does not require large vessels but some inspection equipment, such as ROVs, are necessary. Substation maintenance and service has the lowest barriers to entry since trained and experienced technicians are the main source of investment. Figure 29 summarises our conclusions.

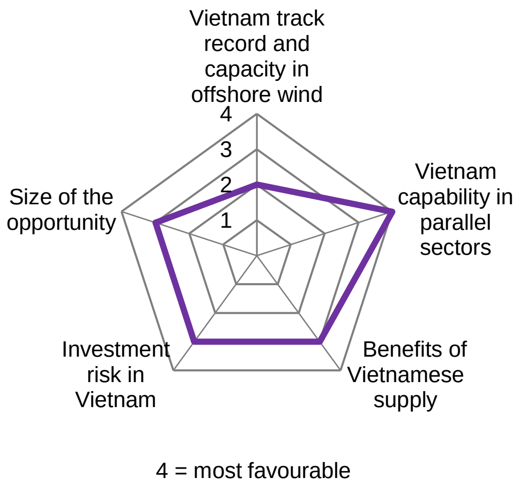

Figure 29 Assessment of supply chain for balance of plant maintenance and service.

4.6. Decommissioning

Decommissioning strategies have not yet been developed in established European markets. It is most likely that vessels and service providers that have been used for installation will also support decommissioning. The number of Vietnamese companies with the potential to provide decommissioning services is shown in Figure 30.

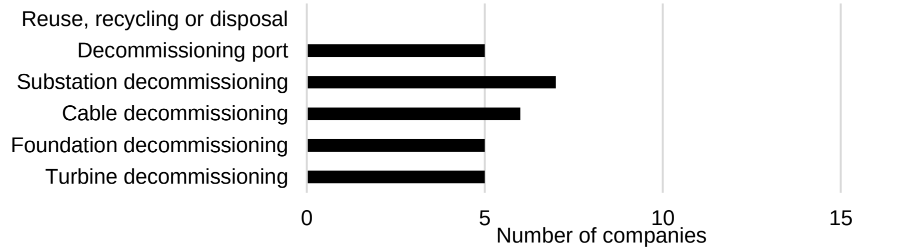

Figure 30 Number of current or potential future suppliers of decommissioning services in Vietnam.

Key potential suppliers include Huy Hoang Logistic & Transportation, OEI, PTSC, Thien Nam Offshore Services and Vietsovpetro. Most of these companies have operation bases in the South of Vietnam. They provide services at a local level to Vietnamese projects.

These companies all have experience in heavy lift operations in the oil and gas industry. Several reported plans to invest in lifting equipment and vessels that will enable them to perform installation and decommissioning operations for offshore wind projects.

There are fewer companies in the Vietnamese supply chain capable of cable decommissioning. This is an opportunity for international service providers who are operational in more established markets. In addition, no companies are reportedly capable of reusing, recycling or disposing of offshore wind farm components. This is likely to increase as the industry matures.

It is likely that Vietnam's capability in this area will increase in this area of the supply chain, as companies invests in installation vessels to service the growing domestic offshore wind market. Figure 31 summarises our conclusions.

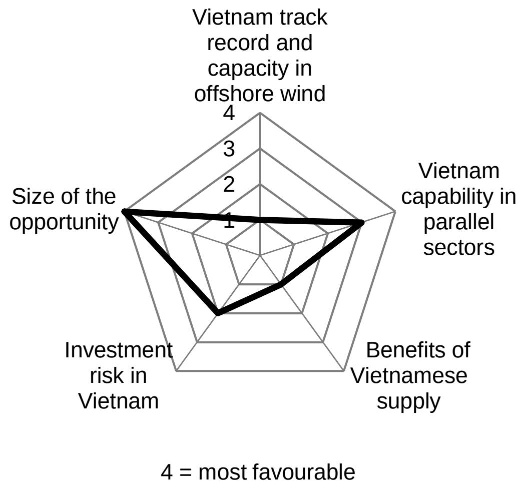

Figure 31 Assessment of supply chain for decommissioning.

5. Port infrastructure

Summary of ports assessment

Ports overview

Vietnam has a coastline of over 3,000km, with 320 designated ports. Vietnam has 44 sea ports with the largest terminals located in Hai Phong, Da Nang and Ho Chi Minh City. Vietnamese ports are owned and managed by a mix of state-owned and private enterprises.

Results

The ports assessment looked at the capability of 15 Vietnamese ports to support offshore wind manufacturing and construction. It found that most of these ports have the space to serve the offshore wind industry, but all required some level of upgrade to infrastructure or facilities.

Six ports were identified as suitable after minor upgrades costing less than US$5 million for each port. This would generally involve minor upgrades to the bearing capacities of quayside and lay down areas and widening or deepening of the approach channels.

Seven ports were deemed suitable for offshore wind activities following moderate upgrades costing between US$5 million and US$50 million. Many of the ports in this category would require more extensive reinforcements to bearing capacities and improvements to storage areas.

Two ports were classified as suitable if subject to major upgrades costing greater than US$50 million. Improvements would include significant extension of quaysides and reclamation of land for storage and port facilities. It is unlikely either of these ports will be selected or upgraded for offshore wind purposes.

The assessment identified a cluster of potential ports located in the southern region of Vietnam located in Ho Chi Minch City, Phu My and Vung Tau. Seven of the ports in this region were identified as requiring only minor or moderate upgrades. In addition, a significant proportion of the existing nearshore and proposed conventional offshore wind projects are in this region. These ports are likely to see the greatest offshore wind activity. The results are summarised in Table 3.

Table 3 Summary of manufacturing and construction ports for offshore wind in Vietnam.

	Port	Suitable for construction	Suitable for manufacturing
1	Hyundai Vinashin Shipyard	Minor upgrades	Minor upgrades
2	Vietsovpetro Port	Minor upgrades	Minor upgrades
3	Tan Cang Cat Lai Terminal	Minor upgrades	Minor upgrades
4	Tien Sa Port	Minor upgrades	Minor upgrades
5	PTSC Port	Minor upgrades	Minor upgrades
6	Tan Cang – Cai Mep Terminal	Minor upgrades	Minor upgrades
7	Thi Vai General Port	Moderate upgrades	Moderate upgrades
8	SITV	Moderate upgrades	Moderate upgrades
9	Cam Ranh Port	Moderate upgrades	Moderate upgrades
10	PTSC Phu My Port	Moderate upgrades	Moderate upgrades
11	PTSC Dinh Vu	Moderate upgrades	Moderate upgrades

	Port	Suitable for construction	Suitable for manufacturing
12	VICT	Not suitable for construction[7]	Moderate upgrades
13	Hiep Phuoc Port	Not suitable for construction[8]	Moderate upgrades
14	Nghe Tinh	Major upgrades	Major upgrades
15	Duong Dong	Major upgrades	Major upgrades

Supplier needs

The offshore wind supply chain in Vietnam is diverse and port infrastructure requirements vary depending upon supplier needs through the phases of a project life-cycle.

Development services

The needs of suppliers involved in the development phase of offshore wind projects are relatively simple. The vessels used to conduct environmental and technical surveys are typically small. The exception is geotechnical survey vessels are often the largest with a length of up to 100m, beam of 20m and draft of around 7m. Survey vessels will use ports to change crews and handle survey equipment. The majority of ports in Vietnam are able to support this function.

Turbine suppliers

In the construction phase, suppliers of turbines and major components need quays to load-out nacelles, blades and towers. Transportation is likely to be via barges or heavy-lift cargo vessels (HLCVs). HLCVs have a length greater than 140m, a beam of around 30m and draft of 7-8m. Barge dimensions are lower.

Load-out of wind turbine components is undertaken by vessel or land cranes. Turbine components require a crane lifting capacity of 500-1,000 tonnes. The quayside and storage area ground bearing capacity also need be within the acceptable limits relative to the component being loaded out. All Vietnamese ports considered in have quayside lengths longer than 200m, except Duong Dong, Nghe Tinh and Hiep Phuoc Port, and can accommodate HLCV. Most of these ports, however, lack the crane capacity and ground bearing capacity to support turbine component load-out.

Balance of plant suppliers

The port requirements for suppliers capable of supplying balance of plant components, such as foundations and substations, are similar to that of turbine component suppliers. As stated previously, most Vietnamese ports can accommodate the size of vessel used to load-out these components. However, these components are heavier than turbine elements and consequently most ports face the same challenges in terms or crane capacity and ground bearing capacity. The exceptions are the Vung Tau PTSC Port and the Vietsovpetro Port which have adequate infrastructure to support turbine and balance of plant component load-out.

Installation services

Installation contractors use larger vessels and therefore the port requirements are greater. Cable installation vessels typically have a length of 130m, a beam of 30m and a draft of 7-8m. Turbine installation vessels can be between 130m and 150m in length, have a beam of 40m and draft of 5-6m. Foundation installation vessels are typically much larger with lengths above 180m, beams of 50m and drafts up to 12m. Substations are usually floated out of the fabrication facility on barges. Most Vietnamese ports can accommodate installation vessels, except for Nghe Tinh, PTSC Port and the Vietsovpetro Port which have shallower channel depths that would prevent foundation vessels from mooring. In addition, VICT and Hiep Phuoc in Ho Chi Minh City, are not suitable as construction ports since the Cau Phu My Bridge enforces a maximum air draft of 55m, preventing

[7] Due to the Cau Phu My Bridge, which enforces a maximum air draft of 55m, preventing the vertical shipment of towers.

[8] As above

the vertical shipment of towers. Most manufactured components are shipped out horizontally and can avoid this restriction.

Operations and maintenance services

Operations and maintenance ports are used to service the wind farm during the operational phase. The port acts as a base for crew transfer vessels (CTV) or larger service operations vessels (SOV). Facilities typically include administrative offices, workshops, storage facilities and lifting equipment. Ports to support the operation of wind farms over the 25 or more years of generation typically have much lower requirements and any investment is easier to justify over the long operating life of an offshore wind project. Binh Thuan and Ninh Thuan provinces are well served by ports with facilities that can be used during the operational phase without significant upgrade costs.

Decommissioning

The decommissioning stage of the project lifecycle requires similar vessels used during installation and therefore the same port requirements will be necessary.

Location of potential offshore wind suppliers

There are supply chain companies in Vietnam that will depend on reliable and accessible port infrastructure to supply to the offshore wind industry. Figure 32 shows a map of manufacturing and construction ports relevant to proposed offshore wind project locations. It also illustrates where current and potential suppliers and projects are in relation to these ports. Only companies that currently have the potential to supply or handle large components have been included in Figure 32 since they are likely to have the greatest need for port infrastructure. The location of development and operations service providers is less dependent upon port infrastructure.

There is a cluster of potential ports located in the southern region of Vietnam with the potential to serve the offshore wind industry.

CS Wind and SRE are both located in the Phu My region. CS Wind's fabrication yard is not located immediately on a quayside but is within 3 km of Thi Vai General Port, Saigon International Terminals and PTSC Phu My Port. It has previously used these ports to load-out tower sections. SRE also has the potential to supply tower sections, along with monopiles and transition pieces. SRE has its own quayside from which it can load-out components.

There are several oil and gas fabricators, such as Alpha ECC, PTSC, Slåttland, and Vietsovpetro, located in the Vung Tau region. These manufacturers all have the potential to supply foundations and substations to the offshore wind industry. Vietsovpetro and PTSC have their own port facilities from which they operate and Slåttland and Alpha ECC has direct quayside access. PVC MS, PTSC Mechanical and Construction and PV Shipyard all operate from the PTSC port. The PTSC port and Vietsovpetro could also be used for construction as it has strong track history in offshore heavy industries, is in a sheltered coastal location and has established port infrastructure to accommodate large vessels, materials handling and load out.

PV Pipe has its own short quayside that it currently uses to load-out steel plates and pipework. It is anticipated that its current facilities would not suit monopile or transition piece production since the quayside length and load bearing capacity would not be suitable for the load out of heavy components to the load. To be able to supply these components, the company would need to considerably extend its facilities.

Several suppliers capable of supplying offshore wind components have fabrication facilities in Ho Chi Minh City. CADIVI could supply array cables and Thu Duc Electro-Mechanical could supply transformers and other high voltage equipment. Both would most likely use VICT or Hiep Phuoc Port to export since it is close. Thyssenkrupp has steel fabrication facilities in Ho Chi Minh City and has suggested it could manufacture turbine bearings in Vietnam. These components can be transported via road and do not need direct port access.

Doosan has a production facility in central Vietnam, south of Da Nang. It has the potential to manufacture substation structure. It has its own quayside facility that is uses to load-out large steel structures.

There are several suppliers with facilities that are not close to port facilities in the Hanoi and Haiphong regions. ABB, EEMC and Hapam could supply high voltage electrical systems for substations from their production facilities in Hanoi. Although these are large components, it is not essential to have direct port access since these components could be transported to the port by road. The same applies to GE's generator factory in Haiphong. If the LS Vina Cable and System factory was to supply subsea cables, it would need to relocate to a coastal facility. In addition, the Lilama EMC facility is inland and not suited to the supply of jackets and other foundation structures.

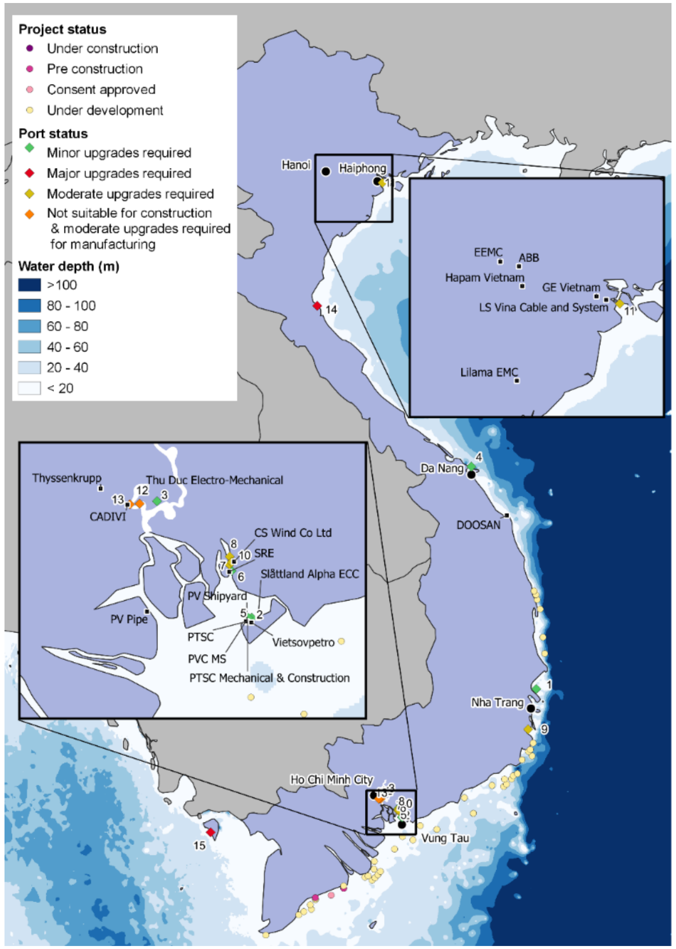

Figure 32 Offshore wind manufacturing and construction ports in relation to current and future potential suppliers and projects.

New insights from supplier engagement

Respondents confirmed that that there are several ports capable of meeting the requirements of offshore wind manufacturing and construction. These are ports that mainly that serve the oil and gas industry in southern Vietnam. Respondents confirmed that there are presently no ports dedicated to offshore wind and that there is a need to invest in upgrading port infrastructure.

The ports that are currently used for offshore wind, especially those in Ba Ria and Vung Tau provinces, are reportedly operating at capacity. This is because they are importing and exporting offshore wind components, as well as general sea freight. This has led to other ports in the Ho Chi Minh City and Vung Tau area to begin handling components for nearshore offshore wind projects, but these ports do not have the facilities to serve conventional offshore wind projects. This confirms the need to establish one or more dedicated offshore wind construction ports in southern Vietnam.

One of the key constraints raised by suppliers for ports is the availability of specialist lifting equipment. PTSC reported that specialist equipment for lifting and unloading heavy components, such as towers, is difficult to source domestically and could hold back the supply chain from developing if not addressed. This is particularly important given Vietnam has CS Wind and other potential component suppliers that rely upon suitable port infrastructure to load-out equipment. In other markets this has not been seen as a major constraint, and so is unlikely to hinder the development of the supply chain.

Improvements to local infrastructure was stated as likely to increase the likelihood of Vietnamese companies supplying to the offshore wind industry. This could include investing in specialist heavy lifting equipment at port facilities, increasing the availability of deep draft ports and improving road-to-port access.

6. Jobs analysis

The number of FTEs created by Vietnamese projects in the low growth and the high growth scenario was modelled. Table 4 shows the number of FTEs created in 2025, 2030 and 2035 in the two scenarios in total, and in Vietnam from Vietnamese projects.

Table 4 Annual number of jobs created in from Vietnamese projects

Where	Scenario	2025	2030	2035
Total	Low scenario	23,800	39,000	62,900
	High scenario	35,000	75,300	85,900
Vietnam	Low scenario	5,000	9,500	15,400
	High scenario	13,700	41,700	48,000

For this study we broke these FTEs down into the demand for workers in different job categories. We considered eight job categories, which covers the majority of the workers needed:

- Engineers
- Factory and civil workers
- Crane operators
- Subject experts – environmental, legal, regulation and financial
- Logistics experts
- Ship crew
- Technicians, and
- Site security and cleaning personnel

The total demand for each job category in the two scenarios in 2025, 2030 and 2035 can be seen in Table 5 and Table 6.

Table 5 Total annual demand for workers in each job category in the low growth scenario created by Vietnamese projects.

Occupation	2025	2030	2035
Engineers	1890	3150	5030
Factory & civil workers	9380	15530	25050
Crane operators	320	500	820
Subject experts - environmental, legal, regulation and financial	1840	3020	4800
Logistics experts	920	1490	2360
Ship crew	3520	5300	8390
Technicians	340	810	1460
Site security and cleaning personnel	130	320	570

Table 6 Total annual demand for workers in each job category in the high growth scenario created by Vietnamese projects.

Occupation	2025	2030	2035
Engineers	2780	6020	6880
Factory & civil workers	14010	30700	34140

Occupation	2025	2030	2035
Crane operators	440	880	1150
Subject experts - environmental, legal, regulation and financial	2760	5820	6450
Logistics experts	1400	2960	3170
Ship crew	5070	9780	11320
Technicians	310	1100	2290
Site security and cleaning personnel	120	430	910

Some of these jobs will be created outside of Vietnam. This study looks at the demand for workers created in Vietnam from Vietnamese projects. Table 7 shows the demand for workers in Vietnam in each job category in the low growth scenario. Figure 33 the annual total demand for workers in Vietnam in the low growth scenario, shown by supply chain category.

Table 7 Annual demand for workers in Vietnam in each job category in the low growth scenario created by Vietnamese projects.

Occupation	2025	2030	2035
Engineers	440	820	1330
Factory & civil workers	1910	3360	5400
Crane operators	60	120	210
Subject experts - environmental, legal, regulation and financial	380	670	1040
Logistics experts	190	320	490
Ship crew	780	1840	2940
Technicians	120	310	580
Site security and cleaning personnel	40	120	220

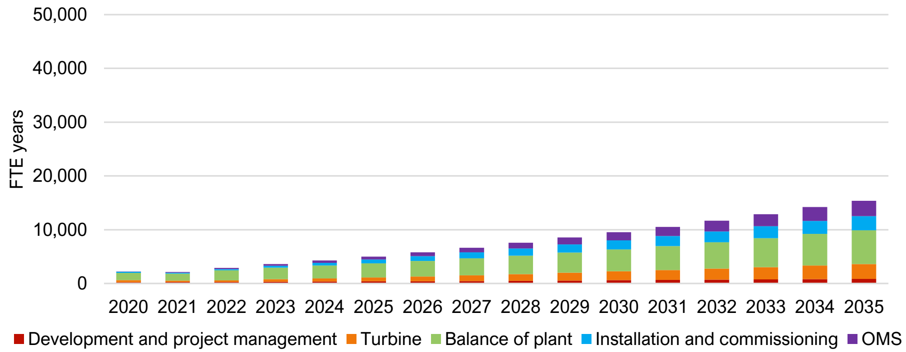

Figure 33 Total annual demand for workers in Vietnam in the low growth scenario by supply chain category.

Table 8 shows the demand for workers in Vietnam in each job category in the high growth scenario. Figure 34 the annual total demand for workers in Vietnam in the high growth scenario, shown by supply chain category.

Table 8 Annual demand for workers in Vietnam in each job category in the high growth scenario created by Vietnamese projects.

Occupation	2025	2030	2035
Engineers	1220	3570	4140
Factory & civil workers	5490	16600	18310
Crane operators	170	530	730
Subject experts - environmental, legal, regulation and financial	1090	3100	3420
Logistics experts	560	1600	1670
Ship crew	1830	5970	7060
Technicians	160	690	1570
Site security and cleaning personnel	60	270	620

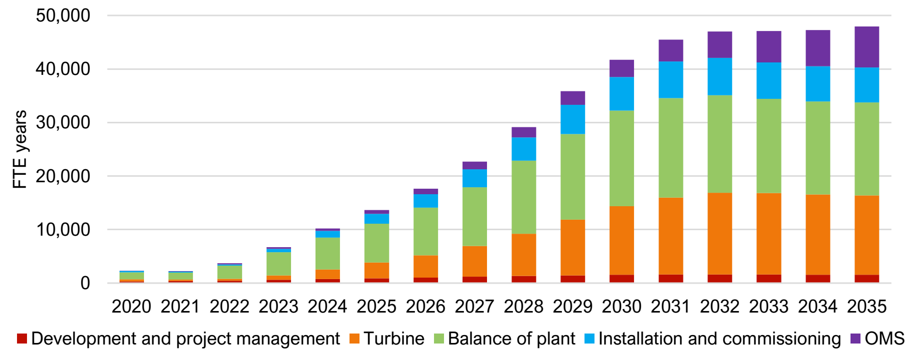

Figure 34 Total annual demand for workers in Vietnam in the high growth scenario by supply chain category.

The section below considers each of the eight job categories.

Engineers

According to *Renewable energy benefits: leveraging local capacity for offshore wind*[9] engineers are required in all supply categories of an offshore wind project, from development and project management, through manufacturing of components, such as turbines and foundation, to installation, commissioning and maintenance of the wind farm.

A range of different types of engineers have been included in this category, including:

- Civil engineers
- Naval engineers
- Electrical engineers
- Mechanical engineers
- Telecommunications engineers, and
- Industrial engineers.

[9] *Renewable energy benefits: leveraging local capacity for offshore wind,* IRENA, available online at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Leveraging_for_Offshore_Wind_2018.pdf, last accessed July 2021

These engineers do not have to be located near the wind farm and can be supplied by global companies. There is additional demand for local engineers in Vietnam, particularly for components that can be supplied by local companies.

In the low growth scenario, the demand for engineers in Vietnam is mainly from the supply of balance of plant components such as foundations and substations. There are also engineers needed for installation and maintenance of the components, and in the development and project management stage. In the 2030s there will also be a demand for engineers related to the supply of towers. The demand for engineers peaks at 1,330 engineers in 2035. Figure 35 shows the annual demand for engineers in Vietnam in the low growth scenario by supply chain category.

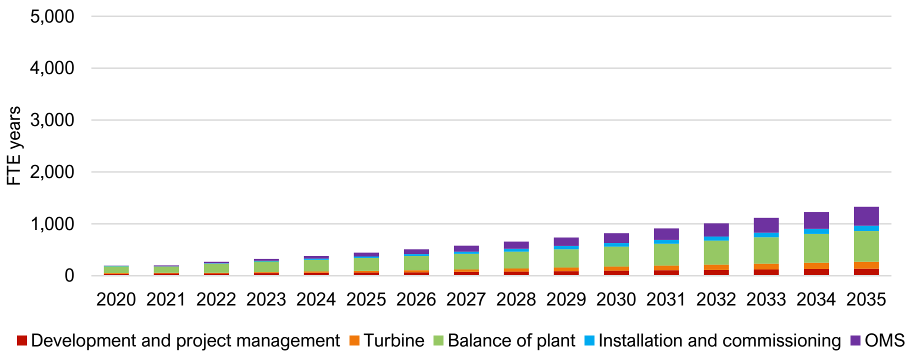

Figure 35 Annual demand for engineers in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, there is a demand for engineers in all supply chain categories. The highest demand for engineers in Vietnam is related to the supply of balance of plant components, including foundations, substations, array cables and export cables. In the 2030s the demand grows for engineers related to the supply of towers, blades and nacelles, as well as for maintenance of all components. The demand for engineers peaks at 4,140 engineers in 2035. Figure 36 shows the annual demand for engineers in Vietnam in the high growth scenario by supply chain category.

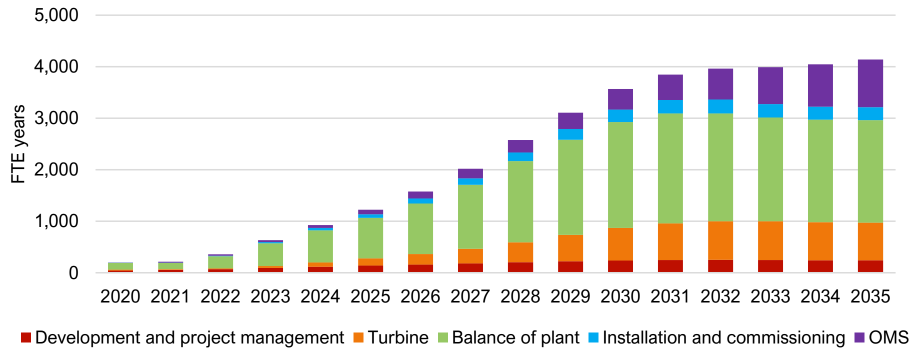

Figure 36 Annual demand for engineers in Vietnam in the high growth scenario, by supply chain category.

Regardless of the field, engineers typically require a degree or postgraduate qualification in the chosen engineering field. A bachelor's degree in engineering in Vietnam is typically 4 years full-time, and a master's degree typically 2 years full-time.

Factory and civil workers

The manufacturing of components for the offshore wind farm, including turbines, foundations, cables and substations, requires a high number of factory workers. These jobs are located where the factories are, and therefore the demand for factory workers will be highest in the areas of the supply chain with the highest local content. In addition, civil workers are required for the maintenance of the wind farm components.

In the low growth scenario, the demand for factory and civil workers in Vietnam is especially around the supply of balance of plant components such as foundations and substations, as well as for the supply of towers in the 2030s. A small number are also needed for the maintenance of the components. The demand for factory and civil workers peaks at 5,400 in 2035. Figure 37 shows the annual demand for factory and civil workers in Vietnam in the low growth scenario by supply chain category.

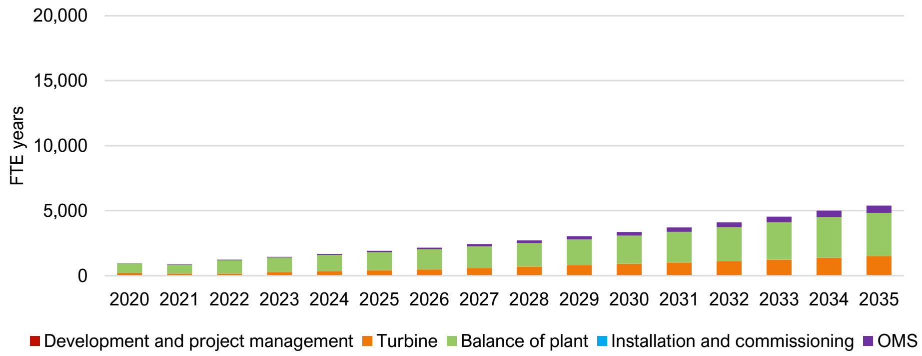

Figure 37 Annual demand for factory and civil workers in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, there is a high demand for factory and civil workers for the manufacturing and supply of components, including foundations, substations, cables, towers, blades and nacelles. There is also some demand for factory and civil workers for the maintenance of components. The demand for factory and civil workers peaks at 18,310 in 2035. Figure 38 shows the annual demand for factory and civil workers in Vietnam in the high growth scenario by supply chain category.

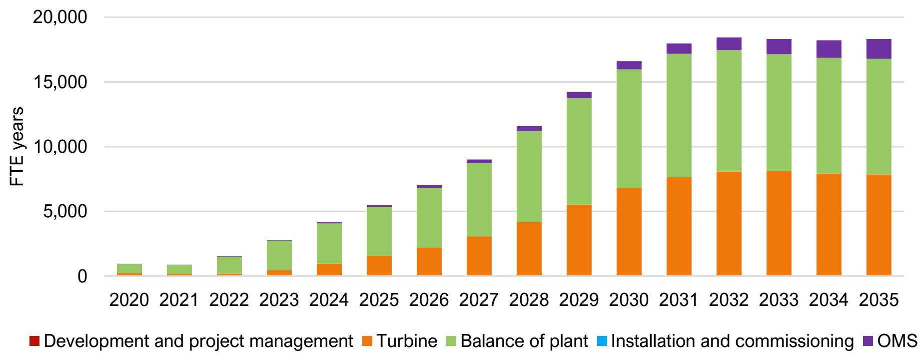

Figure 38 Annual demand for factory and civil workers in Vietnam in the high growth scenario, by supply chain category.

There are no formal qualifications for factory and civil workers, although apprenticeships and vocational training could be an advantage for some. Additionally certain certificates or licences might be required, depending on responsibilities.

Crane operators

Crane operators are required for transport of components from manufacturers, for installation of the components and in the operations and maintenance phase.

These jobs are primarily created locally in Vietnam, the exception being related to the transport of components from manufacturers outside of Vietnam.

In the low growth scenario crane operators are mostly needed for the installation and maintenance of components of the wind farm. A small number of crane operators are also needed for the transport of foundations, substations and towers. The demand for crane operators peaks at 210 in 2035. Figure 39 shows the annual demand for crane operators in Vietnam in the low growth scenario by supply chain category.

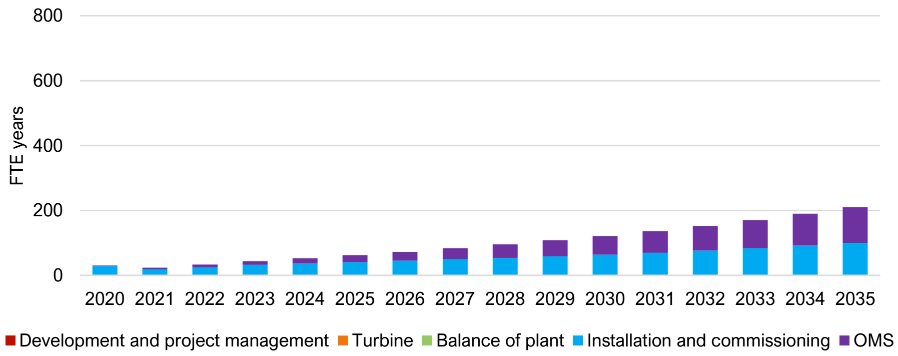

Figure 39 Annual demand for crane operators in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario crane operators are mostly needed for the installation and maintenance of components of the wind farm. A small number of crane operators are also needed for the transport of foundations, substations, cables, blades and towers. The demand for crane operators peaks at 730 in 2035. Figure 40 shows the annual demand for crane operators in Vietnam in the high growth scenario by supply chain category.

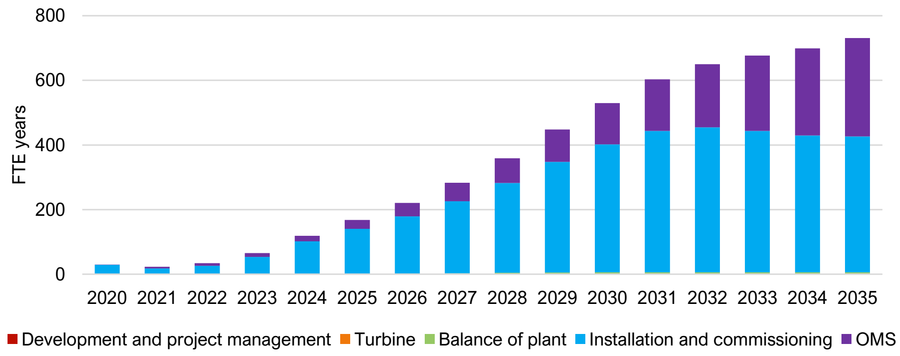

Figure 40 Annual demand for crane operators in Vietnam in the high growth scenario, by supply chain category.

Crane operators typically need training and experience in using heavy plant machinery. A Construction Plant Competence Scheme (CPCS) certificate is typically required as well.

Subject experts – environmental, legal, regulatory and financial

According to *Renewable energy benefits: leveraging local capacity for offshore wind*[10], *a* number of subject experts related to environmental, legal, regulatory and financial subjects are required for the development, construction and operation of an offshore wind farm. These include:

- Environmental experts
- Marine/biological experts
- Sociological experts
- Regulation experts
- Financial experts

[10] *Renewable energy benefits: leveraging local capacity for offshore wind,* IRENA, available online at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Leveraging_for_Offshore_Wind_2018.pdf, last accessed July 2021

- Taxation experts, and
- Legal experts.

These experts do not have to be located near the wind farm and can be supplied by global companies. However, local knowledge is a benefit, and so there is a demand for local experts in Vietnam as well.

In the low growth scenario, the demand for subject experts in Vietnam is the highest in relation to the manufacturing of components. There are also subject experts needed for development and project management, in relation to installation of components and in the operations and maintenance of the wind farm. The demand for subject experts peaks at 1,040 in 2035. Figure 41 shows the annual demand for subject experts in Vietnam in the low growth scenario by supply chain category.

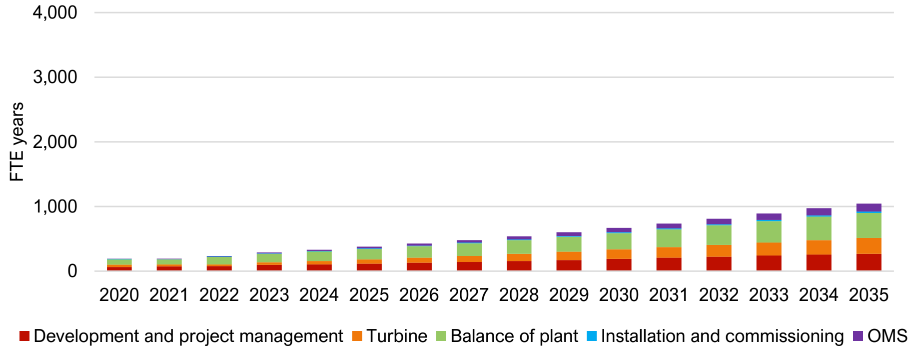

Figure 41 Annual demand for subject experts in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, the demand for subject experts in Vietnam is the highest in relation to the manufacturing of components. There are also subject experts needed for development and project management, in relation to installation of components and in the operations and maintenance of the wind farm. The demand for subject experts peaks at 3,420 in 2035. Figure 42 shows the annual demand for subject experts in Vietnam in the high growth scenario by supply chain category.

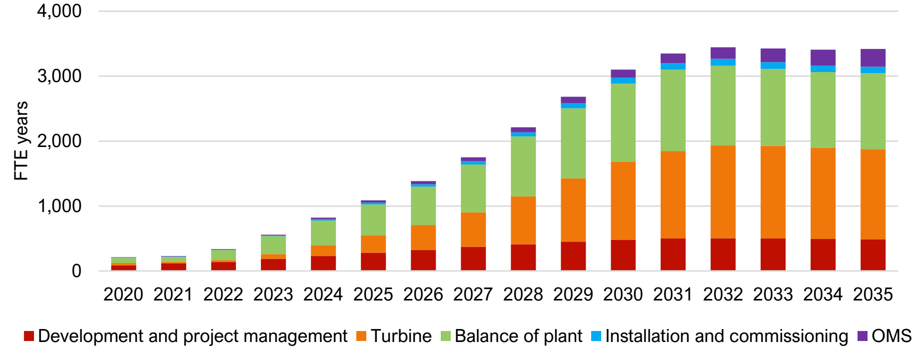

Figure 42 Annual demand for subject experts in Vietnam in the high growth scenario, by supply chain category.

Subject experts typically require a degree or postgraduate qualification in the chosen subject. Depending on the responsibilities involved, several years of relevant experience might also be required.

Logistics experts

Logistics experts are required in the planning phase and for the manufacturing and installation of the components.

There is some benefit of the logistics engineers being local to Vietnam, so there will a demand for local logistics engineers in Vietnam.

In the low growth scenario, the demand for logistics experts in Vietnam is especially around the supply and installation of balance of plant components such as foundations and substations, and towers. There are also a number of logistics expert needed for the development and project management phase. The demand for logistics experts peaks at 490 in 2035. Figure 43 shows the annual demand for logistics experts in Vietnam in the low growth scenario by supply chain category.

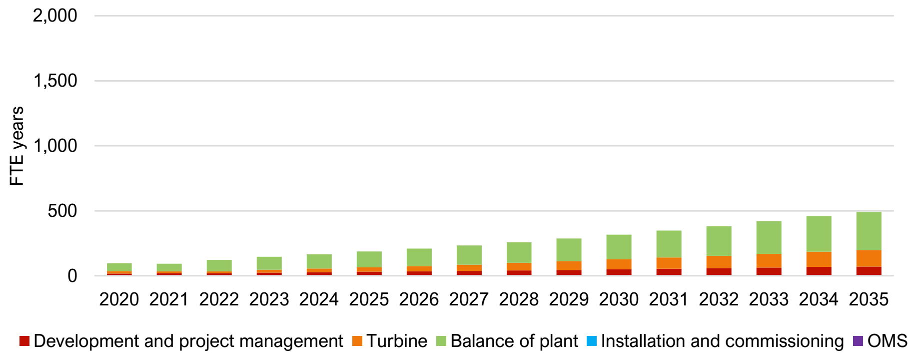

Figure 43 Annual demand for logistics experts in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, the demand for logistics experts in Vietnam is especially around the supply and installation of balance of plant components such as foundations, substations cables, as well as towers, blades and nacelles. There are also logistics experts needed for the development and project management phase. The demand for logistics experts peaks at 1,670 in 2035. Figure 44 shows the annual demand for logistics experts in Vietnam in the high growth scenario by supply chain category.

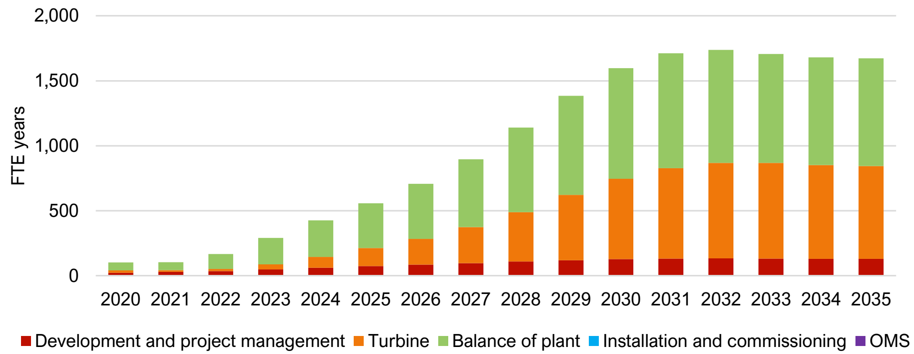

Figure 44 Annual demand for logistics experts in Vietnam in the high growth scenario, by supply chain category

Depending on the responsibilities included a degree in a related field is likely to be required. Experience will be key as well.

Ship crew

Ship crews are required for vessels related to surveys and technical assessments in the development and project management phase, for transport and installation of components and in the maintenance of the wind farm.

Local crews are often used in established markets, and it is assumed Vietnam would be the same, so there will be a demand for ship crew in Vietnam.

In the low growth scenario, the demand for ship crew is highest for the installation of components, such as array cables and export cables. Ship crew will also be needed in the development and project management stage and for the maintenance of components. The demand for ship crew peaks at 2,940 in 2035. Figure 45 shows the annual demand for ship crew in Vietnam in the low growth scenario by supply chain category.

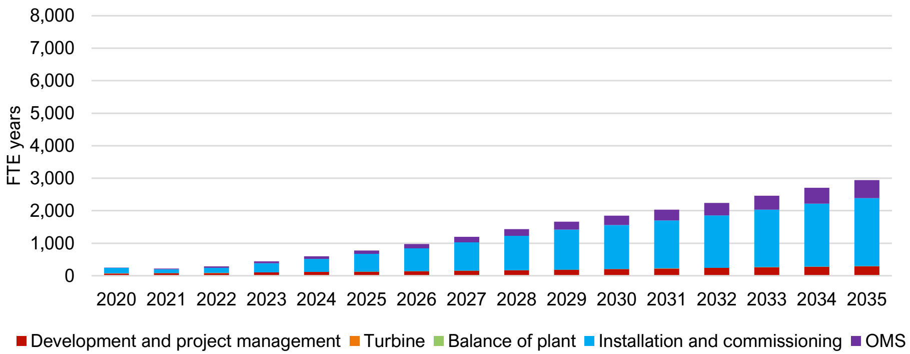

Figure 45 Annual demand for ship crew in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, the demand for ship crew is highest for the installation of components, such as foundations, substations, array cables and export cables. Ship crew will also be needed in the development and project management stage and for the maintenance of components. The demand for ship crew peaks at 7,060 in 2035. Figure 46 shows the annual demand for ship crew in Vietnam in the high growth scenario by supply chain category.

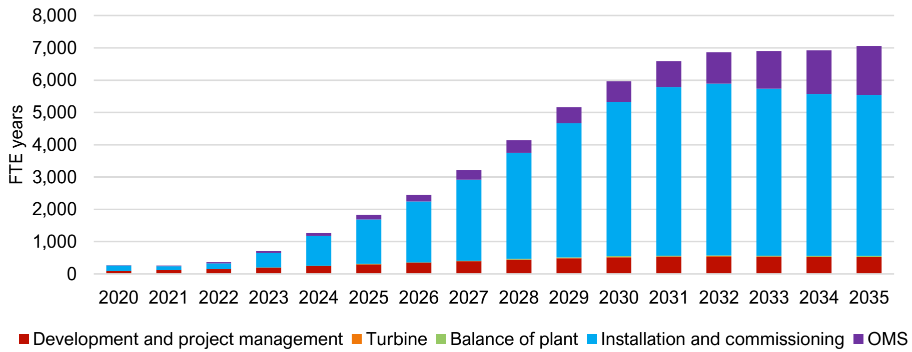

Figure 46 Annual demand for ship crew in Vietnam in the high growth scenario, by supply chain category.

Technicians

Technicians are required in the development and project management phase, and for the supply, installation and maintenance of components.

Some technicians might be provided by global manufacturers, but there will also be a demand for local engineers in Vietnam.

In the low growth scenario, the demand for technicians in Vietnam is highest in the operations and maintenance phase of the project, for maintaining components. There are also a number of technicians needed for installation of the components, and in the development and project management stage. The demand for technicians peaks at 580 in 2035. Figure 47 shows the annual demand for technicians in Vietnam in the low growth scenario by supply chain category.

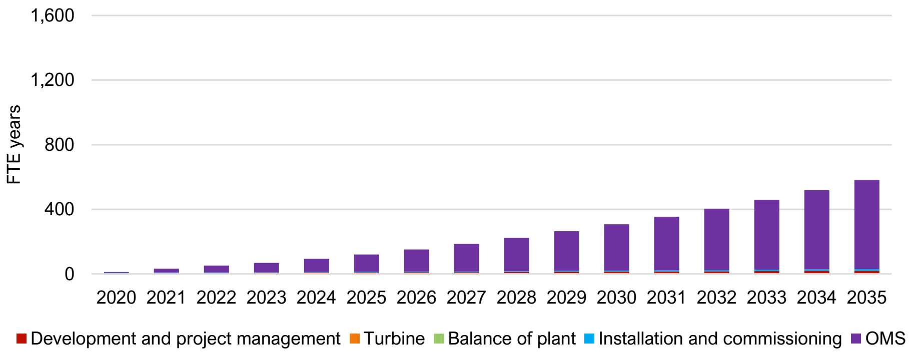

Figure 47 Annual demand for technicians in Vietnam in the low growth scenario, by supply chain category.

In the high growth scenario, the demand for technicians in Vietnam is highest in the operations and maintenance phase of the project, for maintaining components. There are also a number of technicians needed for installation of the components, and in the development and project management stage. The demand for technicians peaks at 1,570 in 2035. Figure 48 shows the annual demand for technicians in Vietnam in the high growth scenario by supply chain category.

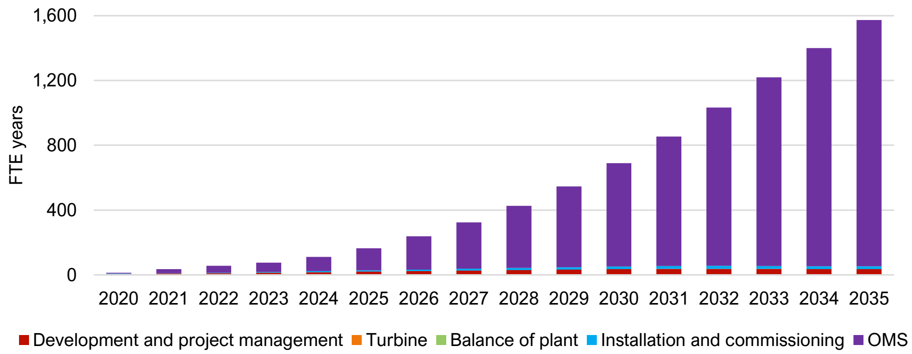

Figure 48 Annual demand for technicians in Vietnam in the high growth scenario, by supply chain category.

The qualifications needed depend on the responsibilities involved. Several global training institutions offer specific wind turbine technicians for example.

Site security and cleaning personnel

There is a demand for security and cleaning personnel related to storage of components before they are installed, and in the operations and maintenance phase.

It is likely that most of the jobs related to security and cleaning personnel will be filled by local workforce.

In the low growth scenario, the demand for site security and cleaning personnel in Vietnam is highest in the operations and maintenance phase. There is also a small demand for site security and cleaning personnel in the manufacturing of the components. The demand for site security and cleaning personnel peaks at 220 in 2035. Figure 49 shows the annual demand for site security and cleaning personnel in Vietnam in the low growth scenario by supply chain category.

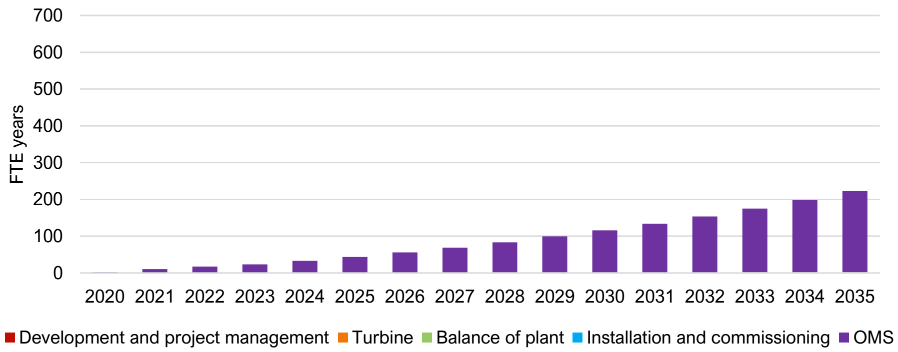

Figure 49 Annual demand for site security and cleaning personnel in Vietnam in the low growth scenario, by supply chain category.

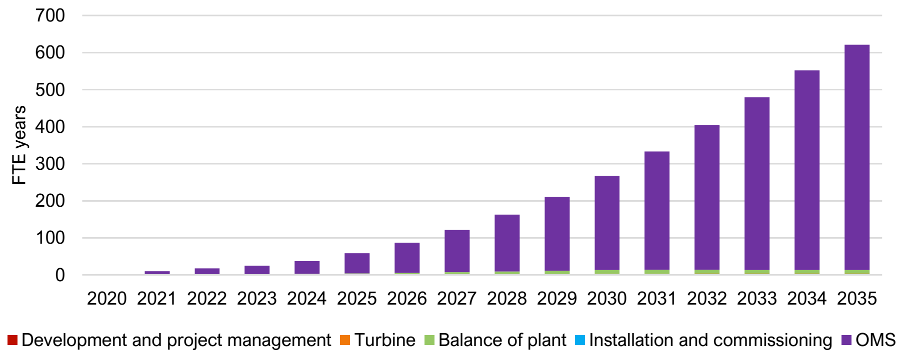

Figure 50 Annual demand for site security and cleaning personnel in Vietnam in the high growth scenario, by supply chain category.

In the high growth scenario, the demand for site security and cleaning personnel in Vietnam is highest in the operations and maintenance phase. There is also a small demand for site security and cleaning personnel in the manufacturing of the components. The demand for site security and cleaning personnel peaks at 620 in 2035. Figure 50 shows the annual demand for site security and cleaning personnel in Vietnam in the high growth scenario by supply chain category.

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7. Supply chain and workforce competence, gaps and opportunities

Status of Vietnamese supply chain

Based on the supply chain analysis, we considered the status of Vietnamese supply for the different supply chain categories. Table 9 summarises the findings.

Table 9 Supply chain by level of recommended Vietnamese intervention

Areas where import most likely	Supply chain in place	Progress likely without intervention	Areas to consider intervention	Areas of priority intervention
Nacelle components Hub castings	Towers Onshore infrastructure	Development and permitting All OMS sub categories Decommission	Blades Subsea array and export cables supply and installation Offshore substation supply (topside and foundation) Nacelle assembly	Turbine foundation supply Turbine and foundation installation

Supply chain areas where Vietnam should prioritise intervention

Methods of intervention to strengthen supply chain capability include:

- Focussed investment in upgrading facilities and infrastructure. Government can directly invest in state owned facilities, or enable private companies to invest through grant support
- Investing in developing workforce skills through focussed training programmes in key areas
- Facilitating capability and quality improvement programmes that develop the capability, skills and readiness of supply chain businesses, and
- Encouraging partnerships between new Vietnamese suppliers and international businesses with existing skills and experience

Turbine foundation supply

Foundations are large items that do not need to interface with other supply chain elements until being installed on site. Local manufacture provides a further benefit in avoiding the costs and risks of transport. Vietnam has transferable skills and facilities in other industries. Combined, these factors make local foundation manufacture a logical supply chain element to establish in Vietnam.

For example, in the emerging US east coast market the first new manufacturing facilities being developed include EEW's monopiles facility at Paulsboro, New Jersey, being developed with South Jersey Port Authority, and the Port of Coeymans, New York, which is upgrading its facilities to enable the production of gravity-based foundations. These examples are developer driven as well as supplier driven due to local content requirements by the state of New York.

Turbine and foundation installation

Modest local content will naturally arise in the installation phase from vessel operations, use of port costs, fuel supply and waste disposal. There are two routes to securing significant additional local content during installation: building large installation vessels, and owning the large installation vessels. Further local content can be captured by installation vessel mobilisation and demobilisation, sea fastener manufacturing, and crew provision.

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Areas of supply where Vietnam should consider intervention

Blades

It is logical for large offshore wind markets to develop local blade manufacturing, given the costs and risks of transporting blades. The leading offshore turbine suppliers manufacture their own blades. Turbine suppliers need to be assured of a significant long-term market to invest in local blade manufacturing. A blade facility needs to close to a quayside as the blades are too large to be moved by road or rail. Vietnam does not have strong transferable skills or facilities from other industries, so significant development and investment will be required.

One example of a new blade factory being established where there was no previous composite experience is the Siemens Gamesa blade factory established in Hull, UK that produced its first blades in 2016.

Array and subsea export cables supply and installation

High-voltage subsea export cables tend to be rated at 220kV and offshore wind is becoming a dominant part of that market so greater levels of production are needed. Cables are easily transported so local supply is not essential. Existing cable suppliers in Vietnam could expand their facilities to supply the offshore wind market, although they will face competition from other suppliers in Asia.

Offshore substation (topside and foundation)

Substation topside fabrication and integration require similar capabilities to oil rig topsides or ship fabrication and fit out. Substation foundations are small in volumes compared to turbine foundations and fabrication require similar capabilities to large steel structure fabrication for oil rig foundation fabrication. Vietnam has several suppliers that could provide offshore substations that would benefit from focussed intervention to strengthen their capabilities.

Nacelle assembly

Accounting for up to 5% of the turbine value, nacelle assembly can be a way of localising at least some of the turbine value. Nacelle assembly can make sense in a market if the manufacture of some other nacelle components are located there too. Vietnam faces competition from other Asian countries in establishing nacelle assembly facilities. Turbine manufacturers will require visibility of a stable long-term market to consider investment in such facilities in Vietnam.

In the US, GE and Vestas have both committed to nacelle assembly at the New Jersey Wind Port as part of supply to Ocean Wind and Atlantic Shores wind farms respectively.

Areas of supply where it is likely that imports will remain the better option for some time.

Nacelle components

Wind turbine suppliers already have an established global supply chain. Part of the required type certification process of their turbines will involve assessing the suppliers of key components as precise and repeatable manufacture is important for safety. Given the size of components and the difficulty of access to them offshore, this is also extremely important to achieve reliability. Key components such as generators are highly specialised, and the area of supply that wind turbine suppliers wish to keep most control as well as how they are assembled and seek to do so at their established factories.

Nacelle assembly may be done locally as mentioned above.

Hub castings

Although made from cast iron since it gives the best fatigue properties for a given mass, the scale and tolerance requirements means that the manufacture of the hub, like key nacelle components, is also part of the type certification and kept to established suppliers.

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Gaps and competencies identified in study

Development, project management and permitting

There are strong transferable capabilities and skills related to development and permitting from other sectors that Vietnamese suppliers can utilise in the offshore wind industry. Gaps in the supply chain include the experience of interpreting survey data related to offshore wind, including environmental data, metocean data and geotechnical data.

Turbine

Gaps in the Vietnamese supply chain relate to turbines include manufacturing of nacelles, blades and electrical systems.

Most ports assessed currently lack the crane capacity (up to 1000 metric tons) and ground bearing capacity (up to 20-30 metric tons/m^2) to support turbine component load-out.

Balance of plant

Vietnam has good capability from other industries when it comes to manufacturing of balance of plant, including foundations and cables.

The gaps in the supply chain related to foundations include handling larger foundation volumes and greater diameters. When it comes to cable manufacturing, gaps include facilities to manufacture higher voltage array cables, which would require suppliers to have confidence in the scale of long-term market opportunity to invest in.

Most ports assessed currently lack the crane capacity and ground bearing capacity to support foundation and substation load-out.

There are no significant gaps related to onshore infrastructure, as there is strong capability from other industries.

Installation and commissioning

Gaps related to the installation and commissioning of the wind farm are related to the lack of Vietnamese turbine foundation or offshore substation installation vessels, and the lack of experience and capability in cable laying.

Installation vessels have a global supply chain, so most likely these will be imported, particularly for early projects.

Turbine installation contractors might make the decision to invest in an installation vessel, depending on market volume.

OMS

This is a logical area where Vietnam's existing oil and gas asset management supply chain, and the growing onshore wind supply chain, can diversify into offshore wind.

The key gap is technician competence related to offshore wind.

Decommissioning

There is good transferable competence in Vietnam supply chain.

The key gap is related to cable decommissioning, but this is not likely to be relevant until the 2050s.

Workforce gaps

For the eight job categories we assessed there is a large workforce in other industries with transferable skills and competence that could meet the demand from offshore wind. There is likely to be an increasing demand for engineers for many sectors in the coming decade, but there are many engineering courses offered to increase the workforce to meet the demand.

We found that there is currently a lack of courses related to the energy transition offered by universities, and few courses related to offshore wind specifically. The need for training human resources for offshore wind energy through colleges and vocational training does not yet appear recognised.

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Gaps, barriers and opportunities identified in the supplier engagement

As part of the engagement process, we asked for supplier input on the following:

- Barriers to offshore wind entry
- Barriers to exporting goods and services abroad
- Gaps in workforce competence
- Industries with transferable skills and capabilities
- Actions the Government can take to encourage growth and investment in the supply chain

Barriers to offshore wind entry

The barrier identified by most suppliers was related to policy and regulation. A need for streamlining processes was identified. Lack of clarity and stability due to changing policy causes uncertainty, as does stalled progress in developing laws and policies. A complicated permit to work procedure for non-Vietnamese workers was also identified as a barrier.

Suppliers were concerned about cost competitiveness with nearby markets. This could be related to the cost of imported raw materials, and the price volatility related to the materials. Another concern was the high investment costs for machinery and equipment, especially if it needs to be imported.

Lack of foreign investment and high interest rates from domestic banks was seen as a barrier. Domestic commercial banks were also seen to have cumbersome and time-consuming procedures, due to the lack of experience in investing in wind energy projects. Another barrier identified by small and medium enterprises was the difficulty of accessing finance support from the Government.

Suppliers and workers in Vietnam lack experience from offshore wind projects, due to Vietnam being an emerging market. This can be a barrier when procurement processes often required previous experience. Another barrier identified was related to Vietnamese contractors not having experience in following international construction standards.

Some barriers related to ports, infrastructure and equipment were identified as well. These include a lack of vessels, availability of deep-water ports connected to fabrication sites, and lack of equipment such as big cranes.

Other barriers identified were the lack of a dedicated offshore wind logistics hub, the availability of Global Wind Organisation and Engineering Construction Industry Training Board training and not having access to professional service provider networks.

Barriers to exporting goods and services abroad

Cost competitiveness, particularly related to the price of raw materials and expensive transportation, was seen as a key barrier to exporting goods and services abroad.

Another key barrier identified related to the lack of experience in offshore wind, and therefore a lack of understanding of technical requirements and standards. The lack of experience also makes building relationships more difficult.

Gaps in workforce competence

Key gaps in workforce competence identified was related to language, technical knowledge, awareness of international standards, especially related to health and safety, and offshore wind specific experience.

Industries with transferable skills and capabilities

Industries identified as having transferable skills and capabilities included:

- Oil & gas
- Construction
- Port management
- Marine works and design
- Vessel construction, and
- Fabrication.

Actions the Government can take to encourage growth and investment in the supply chain

The actions the suppliers identified that the Government could take to encourage growth and investment in the supply chain include:

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- Provide a clear strategy for offshore wind with transparent procedures and clear targets, to reduce risk and create a more attractive investment environment
- Reduce taxes on import of equipment and materials
- Concentrate the funding in a few priority areas
- Introduce a requirement for supply chain plans
- Invest in infrastructure, including ports
- Invest in education, skills and training for Government, businesses and the workforce
- Consider incentives or tax breaks to increase cost competitiveness for Vietnamese suppliers
- Develop partnerships with established offshore wind businesses, and
- Communicate your success in other industries, related to manufacturing quality, a highly skilled workforce and volume capability, to the global offshore wind industry.

8. Recommendations

This section provides recommendations that apply across the supply chain, as well as some more specific recommendations related to supply chain categories where it would make sense for Vietnam to invest. Recommendations are relevant to both Government and industry, as close cooperation between them is vital to the success of an offshore wind supply chain in Vietnam.

Encourage growth and investment

- Offshore wind markets succeed where the industry has long-term confidence in Government ambition.
- Set a clear ambition for offshore wind, with clearly defined processes for leasing, permitting and power purchase, and clear capacity targets. This could help attract developers and investors, and create momentum.

Promote the Vietnamese supply chain

- Engage early with international suppliers and developers.
- Proactive marketing through trade missions and industry events.
- Create offshore wind clusters of capability and competence, where suppliers located close to one another are connected and promoted through a central cluster body.
- Encourage local businesses to partner with each other where it makes sense to reduce interfaces.
- Invest in and drive technological innovation.
- Consider measures to increase cost competitiveness for Vietnamese suppliers such as business and process improvement programmes.
- Consider providing Government support for local contractors bidding for overseas projects, including subsidies or tax reduction.
- Train workers to upskill workforce, leveraging international expertise where relevant.
- Identify partner countries where there is mutual benefit (inward investment in projects in Vietnam).
- Consider publishing an Energy Transition strategy that allows for planning of the training needed for the job transition to renewable energy.

Provide suppliers with advice on how to enter offshore wind market

- Demonstrate how experience from other sectors can transfer to offshore wind.
- Be prepared to show strong health and safety and product quality record.
- Get familiar with technical and commercial requirements of offshore wind including technical standards, financing requirements, and contracting structures.
- Seek to learn from international partners and contractors on early projects and from this develop local competence.

Partner with established suppliers

- Encourage joint-ventures in Vietnam with experienced suppliers.
- Establish what the value add is for partnering, this could be for example using local labour.
- Highlight the value of local knowledge, such as supply chain and regulatory relationships.

Raise awareness and capture opportunities

- Encourage buyers to be transparent about opportunities, by proactively engaging with local supply chain.
- Implement a supply chain data base and an opportunity advertising portal .
- Develop the understanding across Vietnamese industry of the global opportunity in offshore wind, and of what the market needs (products) and demands (quality and cost).

Agree how Government and industry should communicate about the opportunity

- Be ambitious when setting goals, but be realistic about what is possible and reasonable, to avoid stifling development.

- Agree a shared ambition for supply chain development with industry.
- Agree shared programmes for to educate supply chain about offshore wind, especially around international standards, financing and commercial contracting
- Implement programmes similar to the Offshore Wind Growth Partnership[11] and Fit For Offshore Renewables[12] currently used in the UK.

Target investment to the areas of greatest strategic need in the supply chain

- Prioritise intervention in turbine foundation supply and turbine and foundation installation.
- Consider intervention in blades, array and subsea cable supply and installation. Offshore substation topside and foundation supply and nacelle assembly.

Specific recommendations for these supply chain areas are provided below.

Turbine foundation supply

- Explore the opportunities to attract at least one leading offshore foundation supplier to invest together with a waterside facility owner. Such waterside facility locations need to be future-proof to cope with the larger foundations of the future. This means identifying suitable sites with appropriate access and appropriate vessel draft (air and water), and assisting in establishing them.
- Assist the Vietnamese firms most capable of monopile and jacket supply to make the investment to increase size and scale and secure sufficient market.
- Look for the potential for Vietnamese firms to partner with existing leading offshore foundation suppliers.

Turbine and foundation installation

- Learn through partnering with international contractors.
- Encourage Vietnamese ship builders to tender for installation vessel building contracts.
- Encourage Vietnamese investors to seek to own existing vessels or finance the build of new ones.

Blades

- Intervene to attract at least one leading offshore turbine supplier to invest in a blade factory in Vietnam. This means providing access to a suitable site with appropriate access and appropriate vessel draft (air and water), and assisting in establishing facilities. This site needs to be future proof to cope the larger blades of the future.

Array and subsea export cables supply and installation

- Explore the opportunities to attract at least one leading subsea export supplier to invest together with a waterside facility owner. This means identifying suitable sites with appropriate access and appropriate vessel draft (air and water), and assisting in establishing them.
- Assist the Vietnamese firms most capable of 66kV subsea cable to make the investment to manufacture these for the market.
- Look for the potential for Vietnamese firms to partner with existing leading subsea cable manufactures (array or export). This also created an opportunity to learn from the experience of the partners.

Offshore substation (topside and foundation)

- Encourage Vietnamese ship builders and large steel structure fabricators to tender for topside fabrication and/or hosting topsides for electrical equipment integration.
- Encourage Vietnamese ship builders and large steel structure fabricators to tender for fabrication of barges suitable to host substation topsides.

[11] The Offshore Wind Growth Partnership is a programme that supports the growth of UK businesses looking to capitalise on the huge opportunities offered by the global offshore wind sector.

[12] Fit For Offshore Renewables aims to help the UK supply chain get ready to bid for work in the offshore renewable energy sector.

- Encourage Vietnamese investor to seek to own existing barges suitable to host substation topsides or finance the build of new ones.

Nacelle assembly

- Explore opportunities to attract at least one leading offshore turbine supplier to invest in local nacelle assembly. This means providing access to a suitable site with appropriate access. This may be achieved through partnering with a Vietnamese company with suitable experience and quayside facilities.

Appendix A Supply chain categorisation

Table 10 Supply chain breakdown

Level 1	Level 2	Level 3
Development and project management	Environmental	Environmental impact assessments
		Environmental surveys
		Benthic environmental surveys
		Fish and shellfish surveys
		Ornithological environmental surveys
		Marine mammal environmental surveys
		Offshore ornithological and mammal surveying vessels and craft
		Onshore environmental surveys
		Human impact studies
		Resource and metocean assessment
	Technical	Geophysical surveys
		Geophysical survey vessels
		Geotechnical surveys
		Geotechnical survey vessels
		Hydrographic surveys
		Engineering and consultancy
Turbine	Nacelle	Nacelle
		Bedplate *
		Main bearing *
		Main shaft
		Gearbox
		Generator
		Power take-off
		Control system
		Yaw system
		Yaw bearing *

Level 1	Level 2	Level 3
		Nacelle auxiliary systems
		Nacelle cover
		Small engineering components
		Structural fasteners
		Condition monitoring system
	Rotor	Blades *
		Structural composite materials *
		Blade root
		Environmental protection
		Hub casting *
		Blade bearings *
		Pitch system
		Hydraulic pitch system
		Electric pitch system
		Spinner
		Rotor auxiliary systems
		Fabricated steel components
	Tower	Tower *
		Steel *
		Tower internals
		Personnel access and survival equipment
		Tuned damper
		Electrical system
		Tower internal lighting
		Coatings
Balance of plant	Export cables	Export cable *
		Cable core
		Cable outer

Level 1	Level 2	Level 3
		Cable accessories
		Cable jointing and testing
	Array cables	Array cable *
	Cables other	Cable protection
	Foundations	Monopile *
		Jacket *
		Transition piece *
		Crew access system and work platform *
		Internal platforms
		Davit crane
		J-tubes, I-tube or monopile entry point
		Corrosion protection
		Scour protection
	Offshore substations	Offshore substation
		Electrical system
		HVAC system
		HVDC system
		Facilities
		Structure
	Onshore substations	Onshore substation
		Buildings, access and security
Installation and commissioning	Foundation installation	Foundation installation *
		Foundation installation vessel *
		Foundation handling equipment
		Foundation installation equipment
		Sea fastenings
	Offshore substation installation	Offshore substation installation *
		Substation installation vessel

Level 1	Level 2	Level 3
	Onshore transmission installation	Onshore substation construction
		Onshore export cable installation
	Cable installation	Offshore cable installation *
		Cable-laying vessel *
		ROV
		Cable-handling equipment
		Cable burial
		Cable burial vessel
		Cable plough
		Trenching ROV
		Vertical injector and jetting sled
		Cable pull-in
		Electrical testing and termination
	Turbine installation	Turbine installation *
		Turbine installation vessel *
		Turbine handling equipment and sea fastenings
	Other installation	Commissioning
		Construction port
		Offshore logistics
		Sea-based support
		Marine coordination
		Weather forecasting and metocean data
Operation, maintenance and service	Operation, maintenance and service	Training
		Onshore logistics
		Offshore logistics
		Crew transfer vessels *
		Service operation vessels *
		Turbine access systems
		Helicopters

Level 1	Level 2	Level 3
		Health and safety inspections
		Health and safety equipment
		Turbine maintenance and service
		Blade inspection and repair
		Unmanned aerial vehicle
		Main component refurbishment, replacement and repair
		Large component repair vessel
		Balance of plant maintenance and service
		Foundation inspection and repair
		Remotely operated vehicle
		Autonomous underwater vehicle
		Cable inspection and repair
		Scour monitoring and management
		Substation maintenance and service
Decommissioning	Decommissioning	Decommissioning
		Turbine decommissioning
		Foundation decommissioning
		Cable decommissioning
		Substation decommissioning
		Decommissioning port
		Reuse, recycling or disposal

* Supply chain area of strategic importance

Appendix B Supplier questionnaire

General Data Collection

The information you provide in this section will be shared with Equinor, MOIT and potentially beyond

Please state the full name of your company

Please provide the point of contact

Please provide the company's website if available

Please list the location of your offices or factories in Vietnam

Please identify which categories of the supply chain you could supply to?
(mark an X on the selected answer)

Development and project management		P.1.1 Environmental impact assessments
		P.2 Environmental surveys
		P.2.1 Benthic environmental surveys
		P.2.2 Fish and shellfish surveys
		P.2.3 Ornithological environmental surveys
		P.2.4 Marine mammal environmental surveys
		P.2.4.1 Offshore ornithological and mammal surveying vessels and craft
		P.2.5 Onshore environmental surveys
		P.2.6 Human impact studies
		P.3 Resource and metocean assessment
		P.4.1 Geophysical surveys
		P.4.1.1 Geophysical survey vessels
		P.4.2 Geotechnical surveys
		P.4.2.1 Geotechnical survey vessels
		P.4.3 Hydrographic surveys
		P.5 Engineering and consultancy (Exp: FEED)
Turbine		T.1 Nacelle
		T.1.1 Bedplate
		T.1.2 Main bearing
		T.1.3 Main shaft
		T.1.4 Gearbox
		T.1.5 Generator
		T.1.6 Power take-off
		T.1.7 Control system

		T.1.8 Yaw system
		T.1.9 Yaw bearing
		T.1.10 Nacelle auxiliary systems
		T.1.11 Nacelle cover
		T.1.12 Small engineering components
		T.1.13 Structural fasteners
		T.1.14 Condition monitoring system
		T.2.1 Blades
		T.2.1.1 Structural composite materials
		T.2.1.2 Blade root
		T.2.1.3 Environmental protection
		T.2.2 Hub casting
		T.2.3 Blade bearings
		T.2.4 Pitch system
		T.2.4.1 Hydraulic pitch system
		T.2.4.2 Electric pitch system
		T.2.5 Spinner
		T.2.6 Rotor auxiliary systems
		T.2.7 Fabricated steel components
		T.3 Tower
		T.3.1 Steel
		T.3.2 Tower internals
		T.3.2.1 Personnel access and survival equipment
		T.3.2.2 Tuned damper
		T.3.2.3 Electrical system
		T.3.2.4 Tower internal lighting
		T.3.2.5 Coatings
Balance of Plant		B.1.1 Export cable
		B.1.1.1 Cable core
		B.1.1.2 Cable outer
		B.1.1.3 Cable accessories
		B.1.1.4 Cable jointing and testing
		B.1.2 Array cable
		B.1.3 Cable protection
		B.2.1 Monopile
		B.2.2 Jacket
		B.2.3 Transition piece
		B.2.3.1 System and work platform
		B.2.3.2 Internal platforms
		B.2.3.3 Davit crane
		B.2.3.4 J-tubes, I-tube or monopile entry point
		B.2.4 Corrosion protection
		B.2.5 Scour protection

		B.3 Offshore substation
		B.3.1 Electrical system
		B.3.1.1 HVAC system
		B.3.1.2 HVDC system
		B.3.2 Facilities
		B.3.3 Structure
		B.4 Onshore substation
		B.4.1 Buildings, access and security
Installation and commissioning		I.1 Foundation installation
		I.1.1 Foundation installation vessel
		I.1.1.1 Foundation handling equipment
		I.1.1.2 Foundation installation equipment
		I.1.1.3 Sea fastenings
		I.2 Offshore substation installation
		I.2.1 Substation installation vessel
		I.3 Onshore substation construction
		I.4 Onshore export cable installation
		I.5 Offshore cable installation
		I.5.1 Cable-laying vessel
		I.5.1.1 ROV
		I.5.1.2 Cable-handling equipment
		I.5.2 Cable burial
		I.5.2.1 Cable burial vessel
		I.5.2.2 Cable plough
		I.5.2.3 Trenching ROV
		I.5.2.4 Vertical injector and jetting sled
		I.5.3 Cable pull-in
		I.5.4 Electrical testing and termination
		I.6 Turbine installation
		I.6.1 Turbine installation vessel
		I.6.1.1 Turbine handling equipment and sea fastenings
		I.6.2 Commissioning
		I.7 Construction port
		I.8 Offshore logistics
		I.8.1 Sea-based support
		I.8.2 Marine coordination
		I.8.3 Weather forecasting and metocean data
Operation, maintenance and service		O.1.1 Training
		O.1.2 Onshore logistics
		O.1.3 Offshore logistics
		O.1.3.1 Crew transfer vessels
		O.1.3.2 Service operation vessels
		O.1.3.3 Turbine access systems

		O.1.3.4 Helicopters	
		O.1.4 Health and safety inspections	
		O.1.4.1 Health and safety equipment	
		O.2.1 Turbine maintenance and service	
		O.2.1.1 Blade inspection and repair	
		O.2.1.1.1 Unmanned aerial vehicle	
		O.2.1.2 Main component refurbishment, replacement and repair	
		O.2.1.2.1 Large component repair vessel	
		O.2.2 Balance of plant maintenance and service	
		O.2.2.1 Foundation inspection and repair	
		O.2.2.1.1 Remotely operated vehicle	
		O.2.2.1.2 Autonomous underwater vehicle	
		O.2.2.2 Cable inspection and repair	
		O.2.2.3 Scour monitoring and management	
		O.2.2.4 Substation maintenance and service	
Decom-missioning		D Decommissioning	
		D.1 Turbine decommissioning	
		D.2 Foundation decommissioning	
		D.3 Cable decommissioning	
		D.4 Substation decommissioning	
		D.5 Decommissioning port	
		D.6 Reuse, recycling or disposal	

Which products or services do you provide to other industries? (Other than Offshore Wind)

Please provide information on facilities (e.g., yard layouts, dock space, crane capacities, workshops, storage etc) if relevant

Anonymous Data

The data in this section will be anonymized and used only by BVGA to guide the analysis

Please outline any expansion or investment plans you have relevant to offshore wind.

In the scale of 1-5, what is your appetite for offshore wind, 1 being very interested and no significant barriers, and 5 being not interested or there are significant barriers to entry.

(mark an X on the selected answer)

(1): very interested and no significant barriers	(2)	(3)	(4)	(5) not interested or there are significant barriers to entry

Please provide your production rate

For example, if you manufacture monopiles, how many jackets do you produce per year? Or how many tonnes of steel if you are a steel company

Please provide your typical lead-time

Is the company public or private?

For example: Is your company a private company, a joint stock company, a state company or another form?

Is there any Government dignitaries involved in the company?

(mark an X on the selected answer)

	Yes
	No
	I don't know
	Others

Please provide if your company has partnerships or joint ventures with overseas companies.

For example, some companies such as Gamesa or MHI Veritas might have a partnership with a local company to manufacture some parts of their turbines

Please outline your experience in supplying to onshore wind projects, offshore wind projects (intertidal, fixed-bottom or floating) or oil and gas projects.

Could you please list number of employees in different types of roles.

(mark an X on the selected answer)

	0	1-5	6-10	11-50	51-100	More than 100
Managers						
Engineers						
Salespersons						
Coordinators						
Blue-collar workers						
Others						

What do you see as your key barriers to supplying to the offshore wind industry?

Appendix C Introduction to offshore wind in Vietnam

Offshore wind offers Vietnam a local, low cost, large scale, clean source of electricity and long-term jobs. It has an opportunity to use this resource to generate up to almost 30% of its electricity by 2050, with the industry continuing to develop beyond this.

Vietnam's latest Power Development Plan 8 (PDP8) includes a provisional target of 3GW of offshore wind by 2030. This target is set to encourage more offshore wind activity in Vietnam, with the first fully offshore projects expected to be constructed in the middle part of this decade. Many projects have already been proposed by Vietnamese organizations and international offshore wind developers.

The World Bank and the Government of Vietnam will soon be publishing a comprehensive roadmap for offshore wind in Vietnam that will set out a long-term vision for offshore wind in Vietnam. This report was authored by BVG Associates.

Offshore wind can be divided into two types of projects:

- **Conventional fixed offshore.** Projects typically in water depths of between 10 and 35 metres, using foundations, installation methods and very large turbines similar to those used in many projects in Europe and elsewhere in Asia. We anticipate that this will make up the bulk of the offshore wind market in Vietnam.
- **Floating.** Projects in deeper water using floating foundations. Commercial-scale projects are likely only to be installed towards the end of the 2020s, but potentially making up half of the newly installed capacity by 2050.

Vietnam also has intertidal wind projects, which are sited close to shore, where access may be directly from land. Foundations typically are concrete-capped piles, turbines used are onshore models, with minor changes. Installation uses simpler barges in calm, shallow waters. Such projects are considered as a hybrid between onshore and offshore wind. Vietnam has established an early pipeline of such projects. We anticipate that following completion of the initial pipeline of intertidal projects in Vietnam, most projects will be conventional fixed.

Equinor is developing offshore wind projects globally and is undertaking a study to develop an understanding of the current and potential Vietnamese offshore wind supply chain capability and workforce competence, carried out by BVG Associates. The work is undertaken in cooperation with MOIT. For more information about Equinor's offshore wind activities globally, please see the following links:

https://www.equinor.com/en/what-we-do/wind.html

https://www.equinor.com/en/what-we-do/empirewind.html

https://doggerbank.com/

https://www.equinor.com/en/what-we-do/floating-wind/hywind-scotland.html

Vietnam has an opportunity to build on the supply chain capability for offshore wind.

Figure 51 and Table 11 below shows a typical breakdown of the supply chain needed for an offshore wind farm. Further information can be found at www.guidetoanoffshorewindfarm.com.

Table 11 Categorisation of the supply chain.

Level 1 category	Level 2 category	Description
Development and project management	Development and project management	Work by the developer and its supply chain including planning consent, front-end engineering and design, project management and procurement.
Turbine	Nacelle, hub, and assembly	Supply of components to produce the ex-works nacelle and hub and their delivery to the final port before installation
	Blades	Supply of finished blades and their delivery to the final port before installation
	Tower	Supply of tower sections and their delivery to the final port before installation
Balance of plant	Foundation supply	Supply of foundations and their delivery to the final port before installation
	Array cable supply	Supply of array cables and their delivery to the final port before installation
	Export cable supply	Supply of onshore and offshore cables and their delivery to the final port before installation
	Offshore substation supply	Supply of the completed offshore substation platform and foundation ready for installation
	Onshore infrastructure	Supply of components and materials for the onshore substation and the operations base
Installation and commissioning	Turbine installation	Work undertaken in the final port before installation and the installation and commissioning of the turbines, including vessels
	Foundation installation	Work undertaken in the final port before installation and the installation of the foundations, including vessels
	Array cable installation	Installation of the cables, including route clearance, post-lay surveys, and cable termination
	Export cable installation	Installation of the cables, including route clearance, post-lay surveys, and cable termination
	Other installation	Onshore works associated with the substation, cables, and operations base; installation of the offshore substation; general offshore logistics
Operation, maintenance, and service	Wind farm operation	Wind farm administration and asset management, including onshore and offshore logistics
	Turbine maintenance and service	Work to maintain and service the turbines, including spare parts and consumables
	Foundation maintenance	Inspection and repair of foundations
	Subsea cable maintenance	Inspection and repair or replacement of cables

Level 1 category	Level 2 category	Description
	Substation maintenance and service	Onshore and offshore substation maintenance and service
Decommissioning	Decommissioning	Removal of all necessary infrastructure and transport to port; excludes recycling or re-use

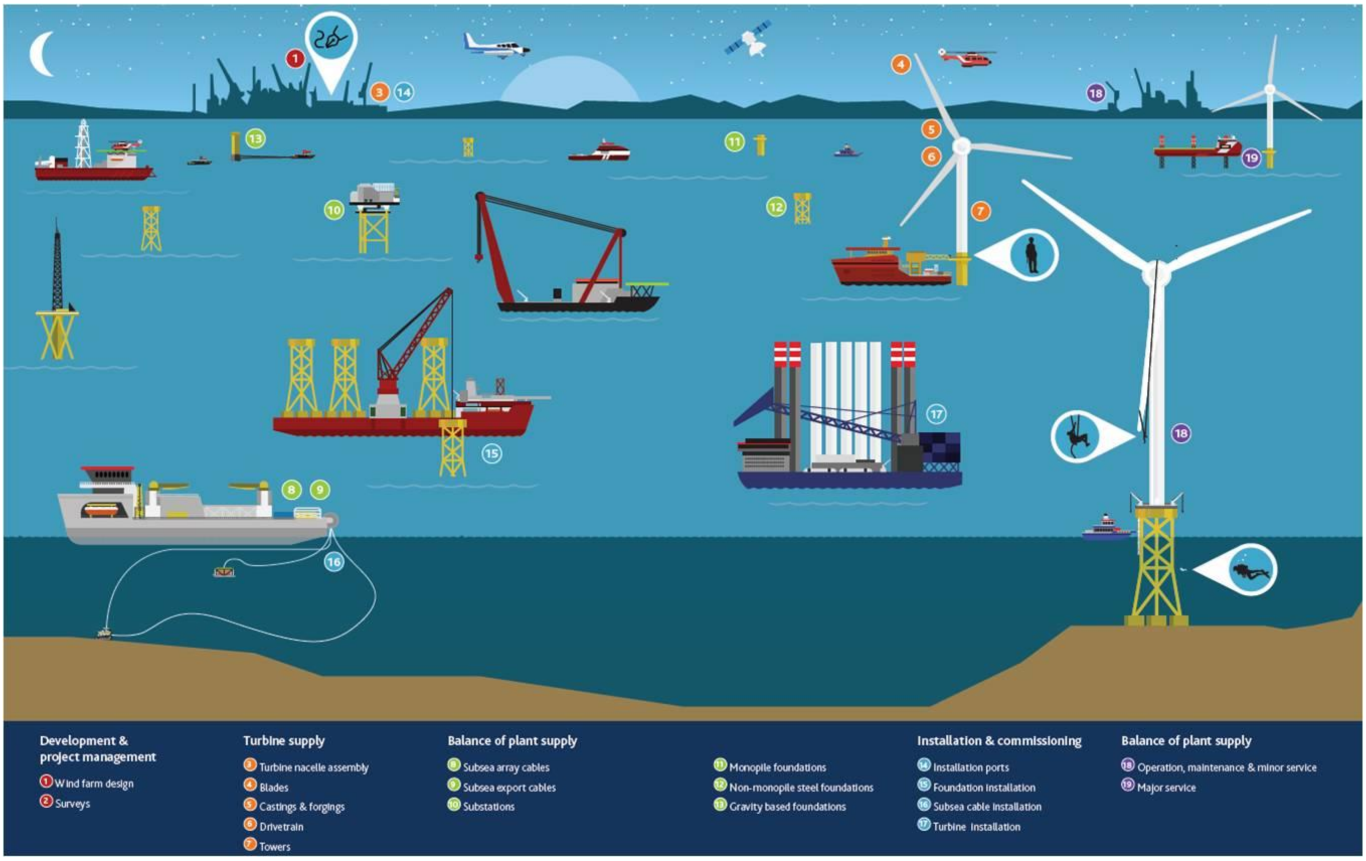

Figure 51 Offshore wind farm supply chain overview