concept consulting

www.concept.co.nz

Offshore wind industry capability mapping study

Prepared for Taranaki Offshore Partnership

October 2023




About Concept Consulting Group Ltd

We have been providing useful, high-quality advice and analysis for more than 20 years. Our roots are in the electricity sector and our practice has grown from there. We have developed deep expertise across the wider energy sector, and in environmental and resource economics. We have also translated our skills to assignments in telecommunications and water infrastructure.

Our directors have all held senior executive roles in the energy sector, and our team has a breadth of policy, regulatory, economic analysis, strategy, modelling, forecasting and reporting expertise. Our clients include large users, suppliers, regulators and governments. Our practical experience and range of skills means we can tackle difficult problems and provide advice you can use.

For more information, please visit www.concept.co.nz.

Disclaimer

Contents

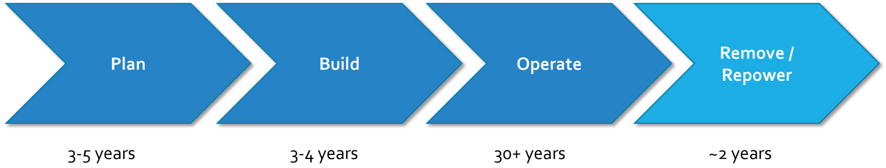
Executive Summary

This report sets out the results of an Industry Capability Mapping study into offshore wind farming (OWF) in Aotearoa New Zealand. This study addresses the following questions:

1. What activities are needed to plan, build and operate an offshore wind farm?
2. What capabilities exist in Aotearoa New Zealand to undertake the activities set out in item 1?

Offshore wind projects have a four-stage life-cycle as shown in Figure 1.

Figure 1: Stages of an offshore wind farm



This report gives an idea of how many jobs could be available during all phases of a project. However, we have focussed more on the operations phase because it lasts for 30 years or more and would generate the most ongoing jobs.

To help make this study tangible, we have used an example of an offshore wind project in South Taranaki with initial capacity of 1,000 MW that can be later increased to 2,000 MW (see Reference Scenario in section 1.5).

We collected information for the study from many sources, including meetings in Taranaki and an online forum. Information on organisational capabilities was collected from a web-based survey and industry research. More than 100 organisations or groups took part in the process.

Photo supplied by: Copenhagen Offshore Partners

Planning phase of offshore wind projects

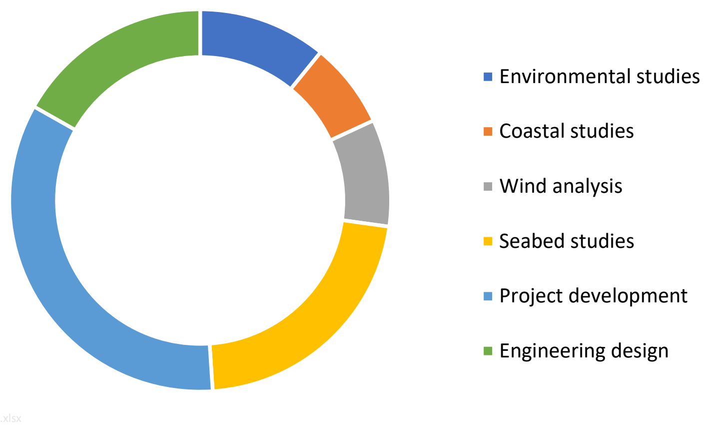
The planning phase[1] of an offshore wind project involves everything needed to decide if the project should go ahead. This includes studying the impact on local communities, the seabed, ecology, and designing the engineering aspects. Overall, we think that planning for a 1,000 MW project would create about 210 person-years of work.[2]

The estimated share of activity among work types is shown in Figure 2.

[1] This analysis assumes procurement activities (such as developing specifications and negotiating contracts with suppliers) are included in the planning phase.

[2] A "person-year of work" is one FTE (full time equivalent) for one year. For example, 10 person-years of work could be one person working for ten years, or 20 people working part (half) time for a year.

Figure 2: Types of work needed in the planning phase



Source: Concept estimate based on IRENA (2018)

We expect that most of the required work could be undertaken by organisations within Aotearoa New Zealand as summarised in Table 1.

Table 1: Scope for domestic involvement in planning work

Category	Potential for supply from sources in Aotearoa NZ
Physical environment studies	Mostly high
Ecological studies	High
Analysis of cultural, social & environ impacts	High
Regulatory consenting	Not assessed
Engineering design and procurement	Mostly high
Commercial analysis	High

More information on work in the planning phase of offshore wind projects is set out in Chapter 3.

Build phase of offshore wind projects

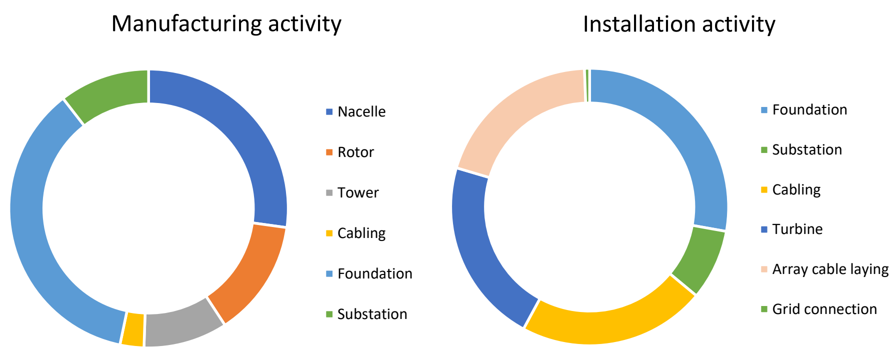
The build phase of an offshore wind project includes constructing all the parts for the wind farm and then installing them at the project site.

Photo supplied by: Copenhagen Offshore Partners, Vineyard Project

Altogether, making the parts for a 1,000 MW wind farm is predicted to create about 8,500 person-years of work. Installing and connecting these parts would add another 1,600 person-years.

The estimated share of activity among major components is shown in Figure 3.

Figure 3: Component level breakdown of work



Source: Concept estimates based on IRENA (2018)

The manufacture and installation of offshore wind turbines needs special equipment and knowledge. Because of this, some components would probably need to come from outside Aotearoa New Zealand.

However, some parts or services could be provided here and there are opportunities for significant local support during the installation phase. For example, local organisations are likely to be well-placed to construct onshore facilities such as a port for day-to-day operations and a connection to the national grid.

A summary of the scope for domestic involvement in the manufacturing and installation phases is set out in Table 2 and Table 3.

Table 2: Scope for domestic involvement in manufacturing sub-phase[3]

Category	Potential for supply from sources in Aotearoa NZ
Nacelle & rotor - supply	Appears unlikely
Tower and transition piece - supply	May be practical for some elements
Foundation - supply	Appears unlikely
Array and export cable - supply	May be practical for some elements
Offshore substation - supply	May be practical for some elements
Onshore infrastructure - supply	Mostly high

Table 3: Scope for domestic involvement in installation sub-phase

Category	Potential for supply from sources in Aotearoa NZ
Nacelle & rotor - install	May be practical for some elements
Tower and transition piece - install	May be practical for some elements
Foundation - install	May be practical for some elements
Array and export cable - install	May be practical for some elements
Offshore substation - install	May be practical for some elements
Onshore infrastructure - install	Mostly high

More information on the manufacturing and installation sub-phases for offshore wind projects can be found in Chapter 4.

Operational phase of offshore wind projects

Offshore wind farms usually operate for around 30 years, or even longer if they are repowered. The operational phase is expected to create the most local jobs because of the nature of its activities and long duration.

[3] For the purposes of comparing categories in Figure 3, Table 2 and Table 3, turbine = nacelle & rotor & tower, and the transition piece is part of the tower.

Photo supplied by: Copenhagen Offshore Partners, Vineyard Project

In its operational phase we estimate that a 1,000 MW project would generate around 3,900 person-years of work. Some of these people would work directly on things like fixing wind turbines, while others would share their time with other projects or jobs, such as helicopter crews.

In full time equivalent terms, the direct and indirect work equates to around 125 roles for a 1,000 MW project.

Most of the people working during the operational phase would likely be from the local area. This is because these roles require people on an ongoing basis, and for them to be physically available to service the offshore wind farm.

The key exception where outside support may be needed is some types of major maintenance work. These sorts of tasks come up every five years or so and need special skills or equipment. However, major maintenance work is expected to also generate demand for local organisations in areas where domestic supply is feasible.

A summary of our assessment is set out in Table 4.

Table 4: Scope for domestic involvement in O&M work

Category	Potential for supply from sources in Aotearoa NZ
Core operation	High
Core maintenance	High
Aviation, port & offshore services	High
Consumables, general services	High
Inspection, certification & environ monitoring	High
Facilities management, and assoc services	High
Human resources	High
Major maintenance - turbines	Mixed
Major maintenance - balance of plant	Mixed
Transport and warehousing	High
survey and research database.xlsx	

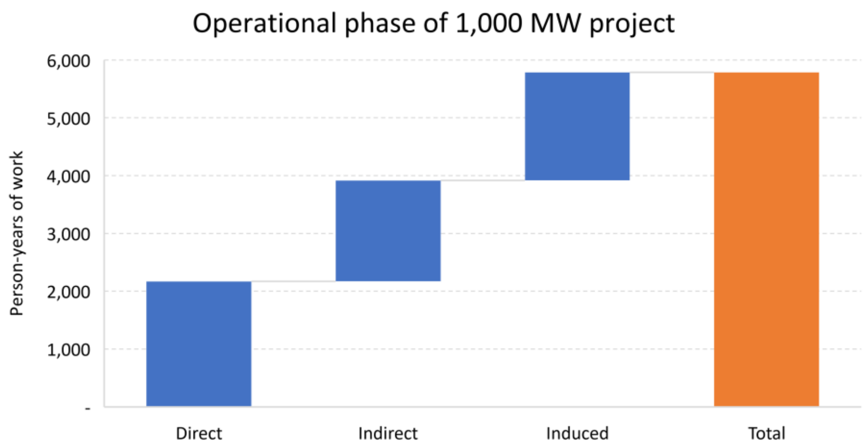
Induced jobs in operational phase

In addition to jobs working on an offshore project itself, the operational phase is expected to create so-called induced jobs.

These are jobs generated in the local area by the additional spending power of people working on the project on an ongoing basis. An example would be the additional workers needed in a local supermarket. For the 1,000 MW reference project we expect around 60 FTE worth of induced jobs.

In total, we expect a 1,000 MW offshore project to generate around 190 FTE jobs and 5,800 person-years of work in the region where the project is located. The estimated impact for each type of work in person-year terms is shown in Figure 4.

Figure 4: Person-years of work in operational phase (1,000 MW project)



Source: Concept estimates

As noted earlier, the Reference Case is based on an initial project size of 1,000 MW that is subsequently expanded to 2,000 MW. We expect a 2,000 MW offshore wind project to generate approximately 9,900 person-years of work in its operational phase, which equates to around 320 FTE jobs.

We have compared our estimates to international data in other similar studies. This comparison suggests that our estimates may be on the conservative side (i.e. more jobs may be generated in practice than indicated by Concept's estimates.)

Possible areas for future research/action

This study is focussed on estimating the scale of job and supplier opportunities from an offshore wind industry.

During this study we have also identified some areas where action could be beneficial to help increase the local benefits from an offshore wind industry.

In broad terms these include:

- Helping local supply chains to prepare and be efficient
- Facilitating collaboration between local and overseas companies
- Helping workers to develop the relevant skills
- Addressing particular hurdles faced by Māori supplier organisations and whānau.

These issues are discussed further in section 6 along with suggestions for future research.

What is offshore wind generation?

Onshore wind farming will be familiar to many New Zealanders with existing wind farms operating from the Waikato region to Southland.

Offshore wind farming is very similar to onshore wind farming in many respects. In both cases generator turbines convert wind energy into electricity which is then injected onto the national grid for use by households and businesses across the country.

Source: Taranaki Offshore Partnership

The key differences between onshore and offshore wind farms are:

- Offshore locations can have better conditions for wind generation due to more steady and higher average wind speeds
- Offshore locations make it easier to use larger turbines which have high efficiency. By contrast, it can be challenging to deploy very large turbines onshore because of the difficulties of transporting components on roads to project sites.
- Offshore locations raise fewer concerns about visual impacts because the turbines can be located well offshore.

1 Purpose and research approach

1.1 Purpose

This report describes the results of an Industry Capability Mapping study of offshore wind farming (OWF) in Aotearoa New Zealand. This study addresses the following questions:

1. What activities are needed to plan, build and operate an offshore wind farm?
2. What capabilities exist in Aotearoa New Zealand to undertake the activities identified in item 1?

While this report scans the entire life cycle for an offshore wind farm, it focuses mainly on the operational phase because that stage endures for 30 years or more and would generate the most ongoing local jobs.

This report also identifies in high level terms some areas where actions could be taken to lift capabilities and ensure more local benefit can be obtained from development of an offshore wind industry in Aotearoa New Zealand.

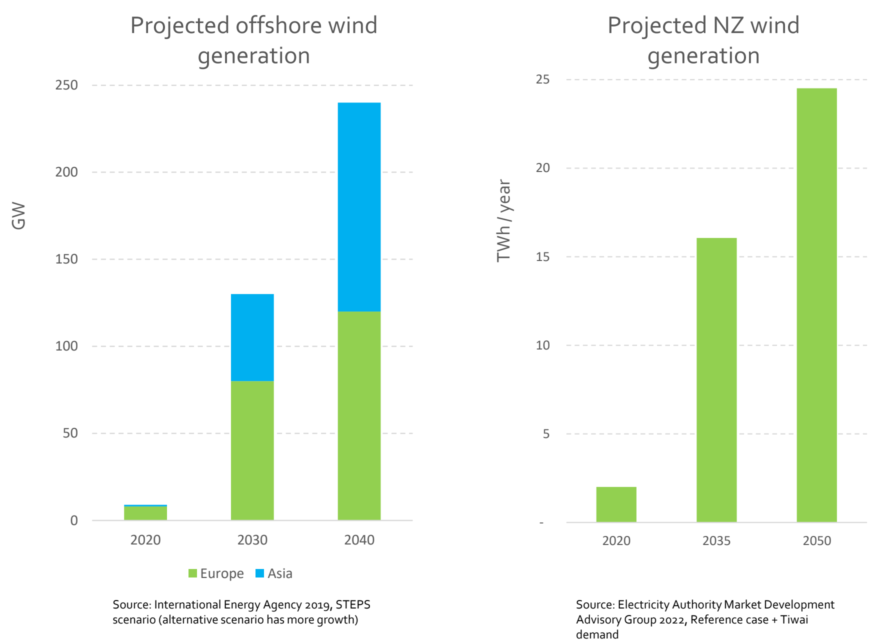
1.2 Decarbonisation driving development of renewables

There are no offshore wind farms in Aotearoa New Zealand at present, but a number of developers are actively considering potential offshore wind projects with initial operation targeted around 2030.

Offshore wind generation began in 1991 and has grown steadily since then. In 2021, an additional 58,000 MW of offshore wind capacity was installed according to the International Energy Agency (IEA).[4] Capacity additions are expected to increase further in coming years.

The main driver for this growth is the pressing need to decarbonise the world's energy supplies.

Figure 5: Projected growth in wind generation



Sources: International Energy Agency 2019, STEPS scenario (alternative scenario has more growth, Electricity Authority Market Development Advisory Group 2022, Reference case + Tiwai demand

As a renewable energy source, offshore wind is expected to play a key role in decarbonisation. This is illustrated by Figure 5. The lefthand panel shows IEA projections of total installed capacity for offshore wind in Europe and Asia. An increase of roughly 2,500% is projected over the period between 2020 and 2040.

Turning to New Zealand, wind generation (onshore and/or offshore) is also expected to play a key role in decarbonisation with much of the growth in new supply expected to come from this source. The is reflected in the righthand panel of Figure 5 which shows a recent projection of wind generation.[5] A roughly ten-fold increase is projected in wind generation between 2020 and 2050.

1.3 Research approach

An approach that is often used in studies of this type is to review the international literature to identify key industry ratios, and then apply them in the local context to derive job estimates. We call this a 'top-down' approach.

This approach has the advantage of not requiring extensive local data and analysis, and also facilitates comparisons across studies. However, the ratios from international studies of previous projects may not necessarily apply to upcoming local projects. This approach therefore needs to be applied with some care.

The alternative 'bottom-up' approach starts by identifying the types of work that need to be performed in a wind farm project. This information is then used to develop position summaries for specific roles. Because this approach starts with more granular information, it should provide a more

[4] www.iea.org/reports/wind-electricity.

[5] The chart shows wind generation and does not specify whether it is onshore or offshore.

accurate picture of the job and work opportunities. However, it is more resource intensive to apply and works best for roles that are dedicated to a particular project.

For this study we have used both top-down and bottom-up approaches to estimate job opportunities, reflecting the fact that each has strengths and weaknesses. In particular, we have used both approaches for the operational phase of a wind project development, given that stage is the main focus of this study.

We have also undertaken qualitative analysis for all phases of a wind project development.

Table 5: Research methods

Phase of wind project development	Top-down Quantitative	Bottom-up Quantitative	Qualitative
Planning	✓		✓
Manufacture	✓		✓
Installation	✓		✓
Operation & maintenance	✓	✓	✓

1.4 Information sources and survey

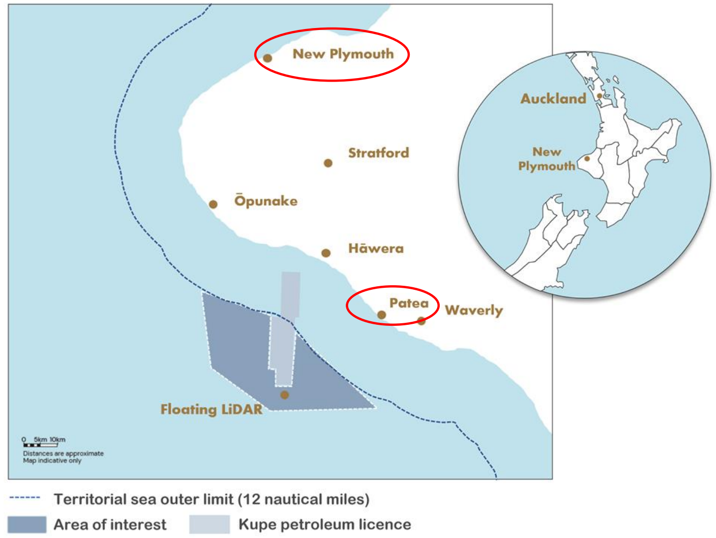
Much of the information specific to Aotearoa New Zealand is based on a survey carried out for this study. Survey data was augmented by information gathered from workshops, hui, bilateral stakeholder discussions and desktop research. A summary of survey responses is contained in Appendix C:.

Information not specific to Aotearoa New Zealand was mainly gathered from industry reports and academic papers. These sources are listed in the reference section at the end of the report.

1.5 Reference scenario

To make this study more tangible, it is based around a notional wind project in the South Taranaki Bight (the so-called Reference Scenario).

Figure 6: Wind project used as Reference Scenario



Source: Concept estimate based on Taranaki Offshore Partnership graphic

Use of specific project parameters allows us to more accurately estimate the numbers of staff required for a wind development in its operational phase. This is because we have specific estimates for the number of turbines and travel distances for crew transfer vessels etc.

The key parameters of the Reference Scenario are set out in Table 6.

Table 6: Reference scenario specifications

Phase of wind project development	Stage	
	1	2
Total MW capacity	1,000	2,000
Commissioning year	2030	-
Turbine count	60-70	120-140
Turbine size	~15 MW	
Water depth	~25-50m	
Foundations	Monopile	
Maintenance strategy	Shore-based vessels & helicopter back-up	
Regular maintenance	Using vessels based in Pātea	
Heavy maintenance	Using vessels from New Plymouth	

1.6 What this study does not cover

Time and resource constraints mean that this report cannot cover every aspect of an offshore wind development. In this context, it is important to note that the study does not include:

- Estimates of jobs/work required to upgrade port facilities to support an offshore wind development. In particular, our estimates do not include the work that would be needed to upgrade port facilities at Pātea and New Plymouth.
- Estimates of jobs/work required to upgrade the electricity transmission grid.
- Estimates of jobs/work required to upgrade other civil infrastructure if that is required, such as development of new housing for workers.
- Estimates of jobs/work opportunities associated with the use of the electricity generated by an offshore wind development.

1.7 Caveats

There will always be a degree of uncertainty when seeking to predict the future. To reflect the uncertainties, we have generally expressed numerical estimates in the form of ranges. These ranges are intended to capture the likely range of possible outcomes.

We note that Aotearoa New Zealand does not currently have a regulatory regime to allow for the development of offshore renewable energy generation. The Government has taken an in principle decision to proceed with a feasibility permitting approach for the feasibility phase of offshore wind farm projects and is currently considering the design of regulation for the construction, operation, and decommissioning phases of offshore wind farm projects.[6]

Some aspects of the work needed to develop an offshore wind project will be affected by the form of a regulatory regime (especially in the planning phase). For this report we have assumed that Aotearoa New Zealand adopts a regime that is broadly similar to that applying in other countries. It is important to note that this is an area of uncertainty.

Finally, we note this study estimates the job opportunities generated by the offshore wind project described in the Reference Scenario. These

[6] See https://www.mbie.govt.nz/dmsdocument/25828-enabling-investment-in-offshore-renewable-energy and https://www.mbie.govt.nz/dmsdocument/26913-developing-a-regulatory-framework-for-offshore-renewable-energy-pdf.

estimates are framed against a counterfactual where no such development occurs.[7]

1.8 Acknowledgments

We greatly appreciate the technical input and information received from the sponsors of this study, Taranaki Offshore Partnership (TOP) and New Zealand Trade and Enterprise. In particular, TOP facilitated access to information on the Star of the South offshore wind project in Victoria and the results from an external study into operation and maintenance requirements for a potential offshore wind development in Taranaki. These sources were invaluable in putting flesh on the bones in many areas of our study.

In addition, we wish to record our sincere appreciation for the engagement support provided by Ara Ake, especially in organising and running the workshops in Taranaki and facilitating information gathering from industry.

We also wish to acknowledge the very useful guidance provided by the Reference Group established to help support this study. The Reference Group members were:

Iwi / organisation	Reference group participants
Ara Ake	Cristiano Marantes, Jonathan Young, Caroline Gunn
Copenhagen Offshore Partners	Giacomo Caleffi, Sarah O'Donnell
Energy Skills Aotearoa	Dianne Mason, Sheree Long
E Tū	Savage, Stefan Freeman, Jen Natoli
NZ Super Fund	Brendon Jones
NZ Trade and Enterprise	Hayden Mackenzie, Will Perriam
Ngāruahine	Te Uraura Nganeko
Ngaa Rauru	Mike Neho, Renee Bradley
Ngāti Ruanui	Graham Young, Nicola Coogan
Taranaki Regional Skills Leadership Group	Charlotte Littlewood
Taranaki Chamber of Commerce	Arun Chaudhari
Taranaki iwi	Mark Wipatene
Te Atiawa	Joshua Hitchcock
Te Pukenga, Western Institute of Technology	Allie Hemara-Wahanui, Kyle Hall
Worley	Philip Furr, Paul Minchin
Venture Taranaki	Anne Probert, Vicki Fairley, Matt Lamb

Our accompanying “Offshore Wind Jobs Guide" draws extensively from a similar document prepared for the Star of the South offshore wind project in Victoria, Australia. We greatly appreciate and acknowledge the assistance provided by the Star of the South project.

Having recorded these acknowledgements, we must emphasise that this report reflects the views of Concept and should not be construed as representing the views of any of the above parties. Likewise, we are solely responsible for any errors or omissions.

1.9 Structure of this report

This report is structured as follows:

[7] In practice, other counterfactual cases could be relevant, such as development of alternative projects.

- Chapter 2 provides an overview of the work required in all stages of an offshore wind project
- Chapter 3 provides more detail on the *planning phase* of an offshore wind farm, the work required and potential capabilities in Aotearoa New Zealand
- Chapter 4 provides more detail on the *build phase* of an offshore wind farm, the work required and potential capabilities in Aotearoa New Zealand
- Chapter 5 provides more detail on the *operational phase* of an offshore wind farm, the work required and potential capabilities in Aotearoa New Zealand
- Chapter 6 describes possible areas for further research.

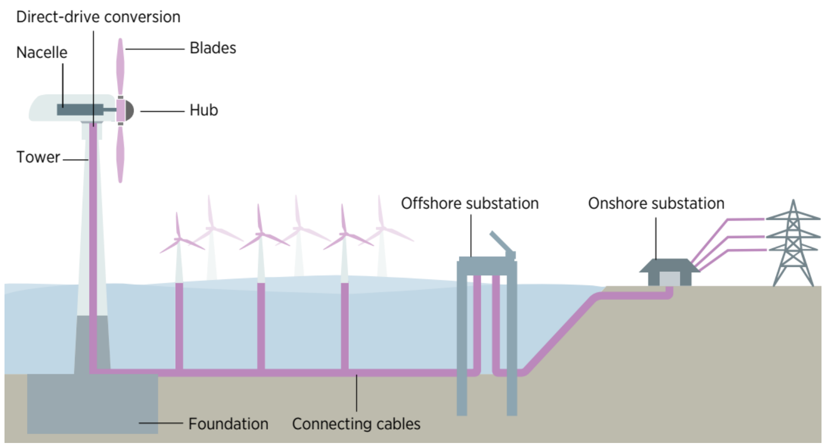
2 Offshore wind projects – overview

2.1 Main elements of an offshore wind farm

Figure 7 shows the main components of an offshore wind farm. Electricity is generated by wind turbine generators (WTGs). Each WTG consists of a rotor (made up of a hub and blades) connected to an electrical generator within a nacelle. The nacelle and rotor assembly can swivel depending on wind direction and is mounted on a tower.

The towers themselves may be fixed to the seabed (as in the diagram) or on a floating structure which is tethered to the seabed. Electricity from each WTG is collected via a network of cables and sent to substations before being injected onto the national grid.

Figure 7: Main components of offshore wind farm

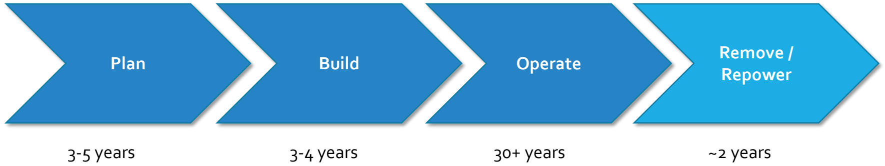


Source: IRENA (2018)

2.2 Life-cycle for offshore wind development

The life-cycle for an offshore wind project has four broad stages, which in total can exceed 30 years. The four broad stages are shown in Figure 8.

Figure 8: Stages of an offshore wind farm



For this study we have focussed on the operation and maintenance (O&M) stage because it produced the most longer-term jobs. For this phase we have used both top-down and bottom-up analysis.

We have also looked at the plan and build phases of a wind farm development. For these phases we have mainly used a top-down analysis to estimate job opportunities. The final phase for an offshore wind farm is the decommissioning and/or repowering of the project. We have not analysed this phase in detail because it is so far into the future. For example, offshore projects currently being planned in New Zealand would likely face repower/decommission decisions around the year 2060 (assuming they proceed around 2030).

Furthermore, experience with onshore wind suggests that if offshore wind projects are developed in New Zealand, they are likely to be repowered at the end of their lives because it makes sense to re-utilise sites with the best wind resources.[8]

Repowering would mean pre-existing infrastructure is dismantled and recycled. New turbines would then be installed to replace the pre-existing equipment. Established pathways already exist to recycle metals which make up the majority of wind farm components. Historically, it has been more difficult to recycle composite components such as blades. However, recent developments mean that recycling of these components has also become viable.[9]

2.3 Work requirements over project life cycle

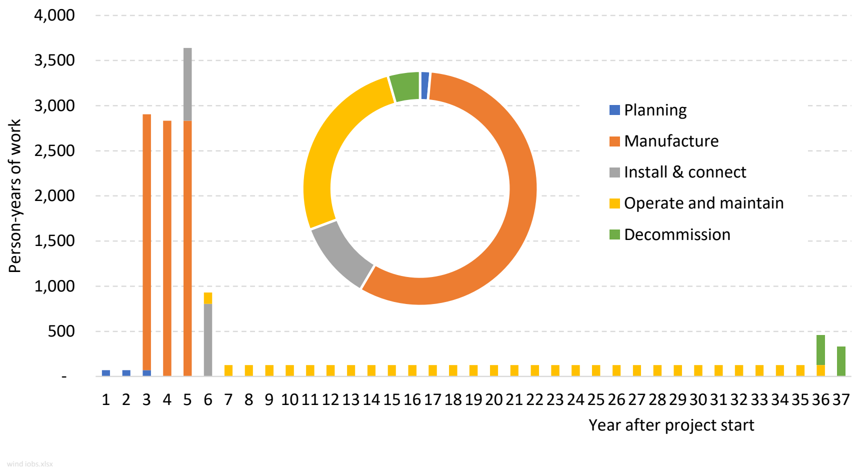
Figure 9 shows the estimated work required for the 1,000 MW wind project in the Reference Scenario over its life-cycle (the derivation of the estimates is explained in later sections of this report).

The chart includes direct and indirect work but excludes induced work. The vertical bars show estimates of work requirements expressed in terms of person-years.

Key observations from Figure 9 include:

- The work profile has a substantial spike in the early years for the plan and build phases. This is followed by decades of relatively steady work required in the O&M stage.
- Manufacture of equipment is expected to be the single largest category of work, accounting for around 57% of the total. As we discuss later, much of this is likely to occur overseas. Nonetheless, there may be opportunities for local input in some categories as discussed in section 4.
- O&M activity is the next largest category of work, accounting for around 26% of the total. It is also the work with the longest duration – i.e. it generates ongoing jobs. Because of this attribute it is covered in some detail in chapter 5.
- The remaining activities (planning, installing and decommissioning) account for around 17% of total.

Figure 9: Person-years of work over life-cycle for 1000MW project



Source: Concept estimates

The following chapters explore each of these phases in more detail.

[8] See https://windeurope.org/newsroom/press-releases/repowering-europes-wind-farms-is-a-win-win-win/.

[9] For example see www.up-to-us.veolia.com/en/recycling/recycling-used-wind-turbine-blades and request.pdf (siemensgamesa.com).

3 Activity in planning phase of a wind project

3.1 Overview of activities in planning phase

The planning phase for an offshore wind project includes all of the activities needed to make a final decision on whether to proceed (the so-called final investment decision). This phase includes the work:

- Obtaining the consents needed to build and operate a project from the relevant authorities
- Examining the impact of a development on affected parties such as mana whenua and local communities and developing plans to address any concerns
- Assessing the effect of a development on the natural environment and developing plans to address any adverse effects
- Designing the wind farm itself
- To procure the plant, equipment and services needed to construct an offshore wind farm.[10] This includes the preparation of specification documents, engagement with potential suppliers, and the negotiation of final contracts.
- Analysing the financial feasibility of the project, including its projected generation output, revenues and costs over its lifespan.

3.2 Estimated work/jobs in wind farm planning phase

As discussed in section 1.1 the planning phase of a wind farm development is not the main focus of this report. For that reason we have compiled a top-down estimate of the work/jobs for this phase rather than a bottom-up estimate.[11]

Photo supplied by: Copenhagen Offshore Partners

In aggregate, we estimate that the planning phase (including procurement activity prior to final investment decision) would require around 210 person-years of activity. The estimated share of activity among work types is shown in Figure 10.

Environmental, coastal, wind and seabed studies account for around half of total activity. All of these activities have a heavy technical component for the gathering and analysis of site-specific data.

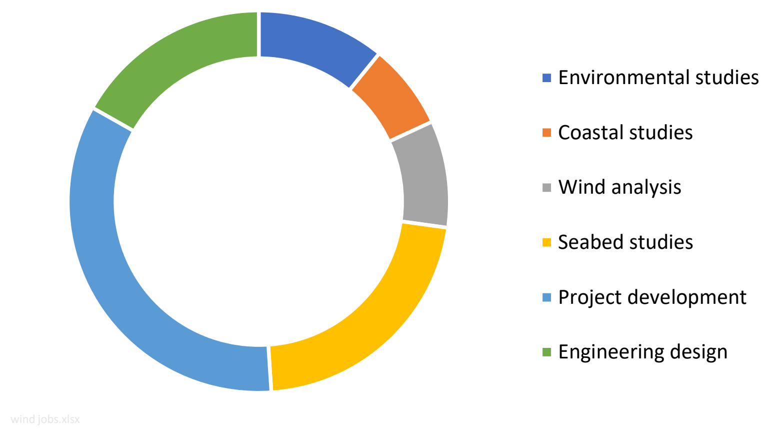
The balance of activity relates to engineering design and project development. The latter category refers to tasks such as applying for

[10] Some steps in the procurement process may occur after a final investment decision. For simplicity we have included procurement in the planning phase.

[11] See Appendix A: for further information.

consents from relevant authorities, negotiating with potential component suppliers, purchasers of electricity, financiers and insurers etc.

Figure 10: Activities in planning phase



Source: Concept estimate based on IRENA (2018)

Table 7 sets out information on the planning phase in tabular form.

Table 7: Work required for planning phase

Types of work	Person-days	Person-years	Share
Environmental studies	3,887	18	8%
Coastal studies	2,592	12	6%
Wind analysis	3,240	15	7%
Seabed studies	7,778	35	17%
Project development	12,234	55	26%
Engineering design	6,012	27	13%
Total	46,691	211	100%
wind jobs.xlsx			

Source: Concept estimates based on IRENA (2018)

Table 8 shows more information on the types of work that would be required in the planning phase.

Table 8: Activities in planning stage of wind farm project

Category	Types of activity	Examples of what is involved
Physical environment studies	Geotechnical survey Multibeam bathymetry Topology/boomer analysis Wind resource assessment and ocean dynamics	Studies to assess the composition of the seabed. Measurement of the depth of water. Used to map the topology of the seafloor. Geological structure of the seabed for foundation design etc. Using mast-based/LiDAR systems to collect data on wind speed and direction, and ocean conditions.
Ecological studies	Benthic flora and fauna (the seabed) Marine mammals Seabirds Fish and squid Onshore species	Methods include: • videography, photography, passive acoustic monitoring, radio telemetry • trawl surveys, purse seining, gill or set nets, aerial surveys, intertidal kaimoana surveys • interviews with fishers, underwater clubs etc
Analysis of cultural, social and environmental impacts of wind farm	Cultural impact assessment Social impact studies Habitat impact (onshore) Habitat impact (offshore) Water quality effects	Engaging with mana whenua iwi on a wind farm's potential effects. Determining whether a region contains any areas of archaeological significance. Identifying social effects (eg, visual impact study and marine traffic study.) Assessing impact on habitat due to infrastructure and operations (eg, vessels and turbines interacting with marine mammals.) Assessing sediment dispersal from construction activities.
Regulatory consenting	Preparing and progressing applications for project consents with relevant authorities	Identifying effect of project on people and the environment. Engaging with stakeholders to discuss effects and address any potential concerns.
Engineering design	Wind farm design Construction planning, transmission, and logistics Operation and maintenance (O&M) planning	Engineering design of all offshore wind farm components. Scoping logistics of major components and port capabilities, transmission connection. Detailing O&M schedules, staff, and logistics.
Commercial analysis	Analyse the costs, and benefits and commercial risks of a development	Modelling of wind generation output (volumes). Analysis of project revenues. Analysis of project costs and taxation. Analysis of financing options.

3.3 Scope for domestic involvement in planning work

For each category of activity in Table 8 we have assessed the scope for supply by people/organisations in Aotearoa New Zealand. While this assessment is inevitably somewhat subjective, we have sought to apply a consistent approach across categories and providers. Key information sources that have been used as inputs for our assessment include:

- Desktop research of business directories etc, past projects etc.
- Information gathered from workshops in Taranaki and online with potential suppliers
- Information provided by Reference Group members
- Information provided by respondents to a survey of potential suppliers.

3.3.1 Physical environmental studies

We expect most of the required capabilities in this category can be accessed within Taranaki or elsewhere in Aotearoa New Zealand. In part, this is due to the cross-over between the requirements for offshore wind and the oil and gas industries. For example, both have a need for offshore geotechnical and bathymetric surveys.

As far as we are aware, the key exception for physical environmental studies is the collection of high-resolution wind and metocean data from floating LiDAR equipment. We understand the equipment itself and the data processing capability need to be sourced from overseas. Having said that, deployment of LiDAR equipment would create opportunities for local support providers (see box).

Overall we assess capability in this segment to be mostly high.

Example of Floating LiDAR

Floating LiDAR buoys can be used to gather highly accurate wind resource and other metocean data for offshore wind developments. Taranaki Offshore Partnership is preparing to deploy a floating LiDAR in the Taranaki Bight in mid-2023. It is expected to remain at sea until at least mid-2024.

The floating LiDAR is being supplied and managed by Akrocean, a specialist firm, based in France. The floating LiDAR supplier has partnered with a local firm, New Zealand Offshore Services (NZOS), to provide local support for onshore and offshore logistics for this project.

NZOS management and technicians based in Taranaki will receive LiDAR and site-specific training from Akrocean. They will provide support for the installation and deinstallation processes and then will carry out scheduled maintenance, such as replacement of consumables and checking of sensors. The local technicians will also be available to assist if any unscheduled maintenance is required.

Photo supplied by Taranaki Offshore Partnership

3.3.2 Ecological studies

We expect most of the required capabilities in this category can be accessed within Taranaki (or elsewhere in Aotearoa New Zealand). Again, this is partly due to cross-overs between the requirements for offshore wind and other existing industries within the country, such as onshore wind which also requires avian studies.

Having made this observation, some work may be needed to scale up local capacity in areas where there has been limited demand in the past. For example, some work may be needed to scale up capacity to undertake marine mammal surveys.

Overall, we assess capability in this segment to be high.

Photo supplied by: Copenhagen Offshore Partners, Star of the South Project

3.3.3 Analysis of cultural, social and environmental impacts

We expect most of the required capabilities in this category can be accessed within Taranaki or elsewhere in Aotearoa New Zealand.

As with earlier categories, some work may be needed to deepen local capacity in areas where there has been limited activity in the past, for example increasing the capacity to assess cultural impacts. More generally, we note that there could be benefits from working with local suppliers because these organisations will have a better understanding of issues on the ground than potential service providers from outside the area.

Overall, we assess capability in this segment to be high.

3.3.4 Regulatory consenting

We have not assessed this category because a regulatory regime for offshore wind has not been established (see section 1.7). Having made this point, if the regime is similar to that in other countries, we expect most of the required capabilities would be able to be provided by organisations within Taranaki or elsewhere in Aotearoa New Zealand.

3.3.5 Engineering design

We expect some of the required capabilities in this category can be accessed within Taranaki or elsewhere in Aotearoa New Zealand. This reflects the strong cross-over between the engineering requirements for offshore wind and some other industries, especially offshore oil and gas production.

Having made this observation, some engineering issues will require knowledge that is highly specific to offshore wind. For example, the optimisation of wind farm layouts is a specialist skillset. It is difficult to assess whether local engineering firms will seek to address these types of gaps through partnerships with overseas firms, or staff recruitment or development, or other means.

Overall we assess capability in this segment to be mostly high.

Photo supplied by: Copenhagen Offshore Partners, LiDAR deployment in Taranaki region

3.3.6 Commercial analysis

Developers are likely to use in-house resources to undertake most of the commercial analysis for an offshore wind development. To the extent that they need external assistance, it is likely to focus on areas such as taxation audit services, drafting of legal documents. We expect that organisations within Taranaki and elsewhere in Aotearoa New Zealand should have the capability to provide those services.

Overall, we assess capability in this segment to be high.

3.3.7 Summary of capabilities in planning phase

Table 9 shows our summarised assessment for each major area of the planning phase, including:

- the potential for domestic provision of services/products in each area
- an indicative list of the potential providers.

We need to emphasise that the list of potential providers is not exhaustive or definitive. There may be potential providers that are not listed. Conversely, listing does not guarantee that a named organisation has all of the necessary capabilities or is necessarily interested in offering the relevant services/products.

Table 9: Potential for local activity in planning stage

Category	Potential for supply from sources in Aotearoa NZ	Comments	Examples of potential providers
Physical environment studies	**Mostly high**	Local organisations appear to have skills/equipment needed for most of the required areas. Some specialist areas will need overseas input (e.g. LiDAR) but these also have potential opportunities for local support.	Discovery Marine Ltd, ENGEO, Fugro NZ, Kingston Offshore, Landpro, New Plymouth Underwater, NZ Offshore Services, NIWA, Oceanum, Offshore and Coastal Engineering, Seaworks, Southern Express, Underwater Solutions
Ecological studies	**High**	Local organisations appear to have expertise needed for most of the required areas. Some specialist areas may benefit from development, marine mammal surveys.	Cawthron Institute, Iwi groups, Martin Cawthorn Assoc, Kaitiaki Collective, Kessels & Assoc, NIWA, Toitū Envirocare
Analysis of cultural, social and environmental impacts of wind farm	**High**	Local organisations appear to have expertise needed for most (or all) of the required areas.	Boffa Miskell, Clough & Assoc, Iwi groups, NIWA, Marico Marine, Mitchell Daysh
Regulatory consenting	Not assessed	Not assessed as consenting regime not yet defined.	BCD Group, Boffa Miskell, Mitchell Daysh, Planz Consultants, Major law firms
Engineering design and procurement	**Mostly high**	Local organisations appear to have expertise needed for most of the required areas. Some specialist areas may need overseas input such as wind data analysis.	Aurecon, Bureau Veritas, COWI, Fugro NZ, Jacobs, Kent PLC, Logicamms, Wood BECA, Worley, WSP
Commercial analysis	**High**	Local organisations appear to have expertise needed to support developers.	Bell Gully, Buddle Findlay, Minter Ellison, Russell McVeigh, Simpson Grierson, Deloitte, EY, KPMG, PWC, and other major accounting and law firms
survey and research database.xlsx			

4 Activity in the build phase of a wind project

4.1 Overview

This build phase for an offshore wind project includes all of the activities from the final investment decision through to the initial commencement of operations.

This phase includes:

- Manufacturing the components needed to build an offshore wind farm, such as wind turbine generators (WTGs), foundations and transition pieces for towers, cabling to convey power to shore and sub-stations.
- Transporting components from factories to the location of the project.
- Installing foundations, WTGs and substations.
- Laying cables and connecting WTGs and substations to the grid.

Much of this work requires specialised equipment or expertise. For this reason, a large proportion of manufacturing and installation activity is likely to be undertaken by organisations based outside Aotearoa New Zealand.

This observation is not unique to offshore wind. It applies equally to onshore wind turbines and other electricity generation technologies such as geothermal plant. Nonetheless, there may be some areas where local manufacture could be viable.

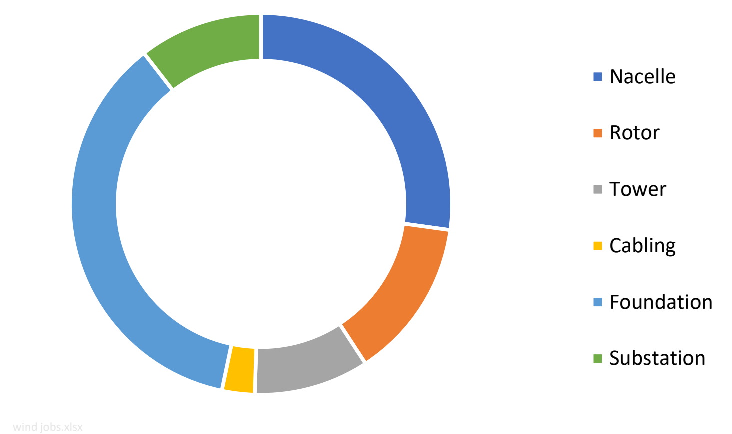
We provide an overview of the manufacturing and installation processes for major wind farm components in sections 4.2 and 4.4, respectively. In sections 4.3 and 4.5 we discuss the areas where localised supply may be viable and/or likely.

4.2 Manufacture of components for an offshore wind farm

In aggregate, the manufacture of wind farm components is estimated to require around 8,500 person-years of activity. The estimated share of activity among major components is shown in Figure 11.

The single largest category is work on foundations which accounts for around 36% of total activity. The next largest in order are the manufacture of nacelles (27%), rotors (14%) and towers (10%). The balance of plant accounts for 14%. It is important to note that these shares reflect the results reported in IRENA (2018). The shares for the Reference Project could be different. For example, the work needed for foundations will be affected by water depth, seabed conditions and choice of foundation type.

Figure 11: Manufacturing activity by major component



Source: Concept estimates based on IRENA (2018)

Table 10 sets out the information on work in the manufacturing phase in tabular form.

Table 10: Work required for manufacturing sub-phase

Component	Person-days	Person-years	Share
Nacelle	510,872	2,312	27%
Rotor	255,432	1,156	14%
Tower	182,958	828	10%
Cabling	52,074	236	3%
Foundation	680,121	3,077	36%
Substation	197,315	893	11%
Total	1,878,771	8,501	100%
windjobs.xlsx			

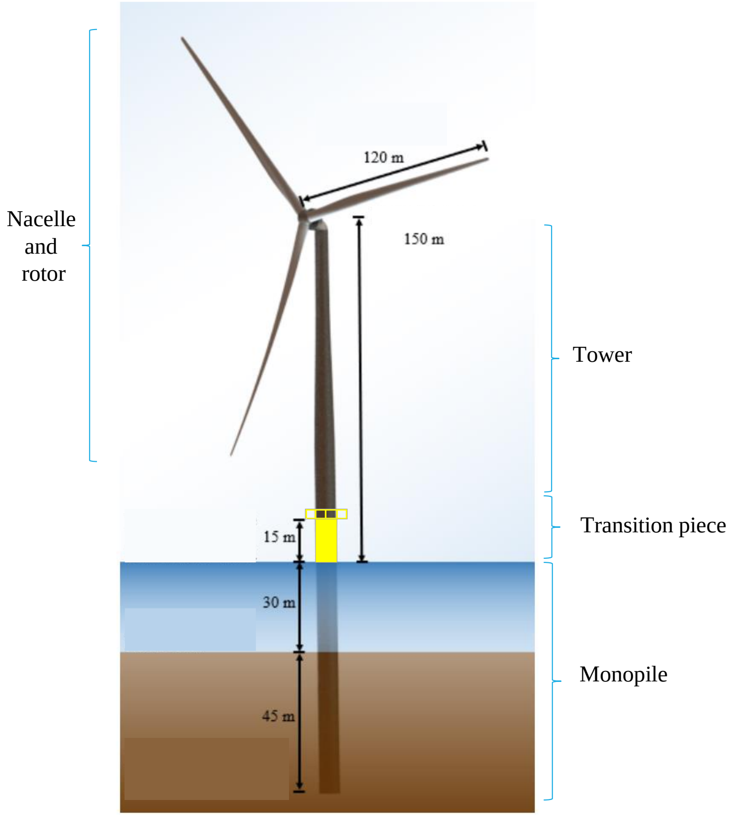
Source: Concept estimates based on IRENA (2018)

4.3 Scope for domestic involvement in manufacturing work

For each category of activity in Table 12 we have assessed the scope for involvement by people/organisations in Aotearoa New Zealand. Key information sources used as inputs include:

- Information provided by Reference Group members
- Desktop research of business directories etc, past projects etc.
- Information gathered from workshops in Taranaki and online with potential suppliers
- Information provided by respondents to a survey of potential suppliers.

Figure 12: Main components of offshore wind turbine



Source: Adapted from NREL (2020)

4.3.1 Nacelle and rotor components supply

Aotearoa New Zealand does not manufacture nacelles or rotor components for large-scale wind turbine generators, and all existing onshore WTGs were made overseas.[12]

In principle, domestic manufacturing of major WTG components might be encouraged by introducing local content requirements. However, that would almost certainly raise costs and therefore make wind developments less likely to occur.

A further impediment for domestic manufacturing of major WTG components is that export sales would also be required to justify manufacturing investment. However, local wind turbine manufacturers would be at a cost disadvantage in export markets because of the country's remote location and the large transport costs for wind turbine components due to their size and specialised requirements.

These factors suggest that domestic manufacture of the nacelle and rotor components is unlikely to be practical.

4.3.2 Tower and transition piece supply

Towers are formed from steel plates that are rolled and welded into cans, that are then joined by more welds to form longer tapering tubes. Plate thicknesses vary within a tower to optimise weight and strength. The indicative range of plate thicknesses for a 15MW turbine is 55mm at the tower monopile joint and 25 mm at the hub junction.[13]

Transition pieces are typically placed between towers and the foundations. Transition pieces have a boat landing which consists of a pair of strong parallel vertical beams (known as "bumper bars"). Crew transfer vessels manoeuvrer to press their bow section against the bumper bars. Service personnel can then step across to a ladder located between the bumper bars, and gain access to the main work platform and the turbine.

The main work platform is large enough to allow the storage of gear and consumables and may include a crane for transferring items to and from crew transfer vessels. The main work platform is surrounded by guardrails and has lights and non-slip decking to provide a safe working environment.

Photo supplied by: Copenhagen Offshore Partners, Vineyard

[12] An exception may be the 0.5 MW Windflow Technology turbines installed in 2006 near Palmerston North. These turbines have since been overtaken by much larger machines.

[13]. See https://www.nrel.gov/docs/fy20osti/75698.pdf

We understand that the manufacture of cans for towers and transition pieces has become highly automated in countries where they are made. It seems unlikely that local manufacture would be competitive given the required investment in specialised equipment. That was presumably one of the reasons that towers for all recent onshore farms have been imported.

However, there may be potential for some tower and/or transition piece components to be manufactured locally at reasonable cost, such as platforms and access ladders. However, this would require a more detailed analysis to assess and is beyond the scope of this study.

4.3.3 Foundations supply

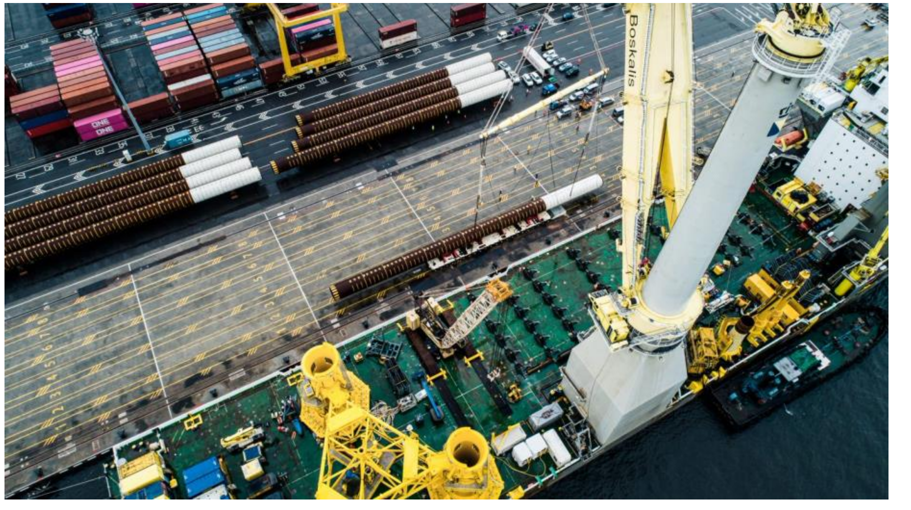
For the reference case we have assumed monopile foundations. The manufacturing process for these is very similar to that for towers, and hence domestic manufacturing appears very challenging.

An alternative to monopiles would be jacket foundations. Jackets are structures with multiple legs (commonly four) which are diagonally braced and support a platform. It appears unlikely that the local manufacture of jacket-based foundations would be economic.

These are large structures that need to be fabricated and assembled close to a port. Aotearoa New Zealand does not have facilities suitable for this type of activity because there is insufficient demand to justify the necessary investment. In this context, we note that the jackets used for oil and gas platforms located off the Taranaki coast have all been fabricated in overseas yards.

More generally, foundations will typically include a J-tube[14] which provides the entry point for the array cable. This is a cylinder with a curved end like a letter J. This allows the array cable to curve smoothly as it transitions between running horizontally on the seabed and vertically in the tower.

J-tubes require less specialised equipment to manufacture than monopiles or jackets and local supply may potentially be practical.



Project Photo supplied by: Copenhagen Offshore Partners, Changfang and Xidao project, Taiwan

4.3.4 Array and export cable supply

Array cables connect individual turbines to an offshore substation and operate at medium voltages (typically 33 kV to 66 kV). Export cables connect offshore substations to shore-based facilities and operate at high voltages (above 66 kV).

[14] In some cases, I-tubes may be preferred. These perform a similar function.

New Zealand has some cable manufacturing capability including a facility located in Taranaki. This is reported to be able to make cables with ratings up to 33 kV[15] but is not clear whether this includes the manufacture of submarine cables.

To determine whether local manufacture of suitably rated subsea cables is economic would require detailed information and analysis and is beyond the scope of this study. However, there may be potential for local manufacturing of array cables and (less likely) export cables.

4.3.5 Offshore substation supply

Offshore substations contain transformers that convert power from each turbine to a higher voltage for transmission to shore. Substations also contain switchgear and other monitoring and safety-related equipment. They can be mounted on a monopile or jacket foundation (see comments in section 4.3.3).

While there is some manufacturing of transformers in Aotearoa New Zealand, we understand this is focussed on the type of equipment needed for electricity distribution networks which are much smaller than the equipment required for power generation. Local manufacture of the transformers for offshore substations therefore appears unlikely to be practical.

However, local fabrication/manufacture of some other components may be feasible. For example, these could include cable equipment, crew accommodation, emergency systems, decking, helipad, boat landing system, etc.

4.3.6 Onshore infrastructure supply

An offshore wind project would need onshore infrastructure including the shore-crossing for export cables, an onshore substation and the operational base. As noted earlier, this would likely include port facilities from which crew transfer vessels would operate.

We expect that domestic suppliers would be capable of manufacturing many of the components required for the onshore infrastructure. This is because those civil construction components have strong synergies with other industries. As far as we are aware, the only major exceptions would be items such as the onshore substation transformers.

4.3.7 Summary of capabilities in manufacturing sub-phase

Table 11 shows our summarised assessment for each major area of the manufacturing sub-phase, including:

- the potential for domestic provision of services/products in each area
- an indicative list of the potential providers.

We need to emphasise that the list of potential providers is not exhaustive or definitive. There may be potential providers that are not listed. Conversely, listing does not guarantee that a named organisation has all of the necessary capabilities or is necessarily interested in offering the relevant services/products.

[15] See https://www.nexans.co.nz/en/Company/What-we-do.html

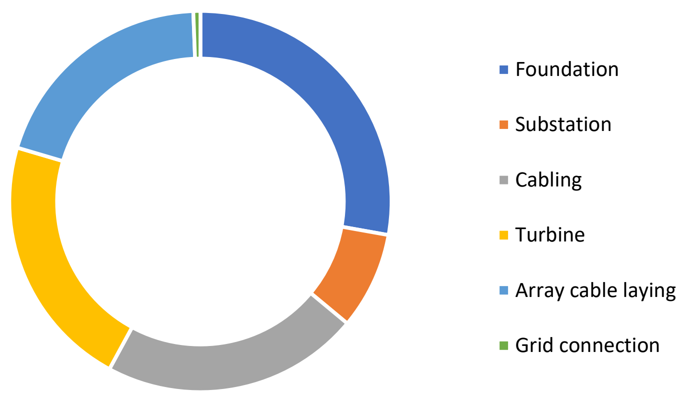
Table 11: Potential for local activity in manufacturing sub-phase

Category	Potential for supply from sources in Aotearoa NZ	Comments	Examples of potential providers
Nacelle & rotor - supply	Appears unlikely	Manufacture requires specialised expertise and equipment	N.A.
Tower and transition piece - supply	May be practical for some elements	Domestic manufacture of some sub-components may potentially be practical - e.g. platforms, J-tubes, boat landings	Brightwater Steel, Dialog Fitzroy, Eastbridge, Steel & Tube, Steelcraft
Foundation - supply	Appears unlikely	Manufacture requires specialised expertise and equipment	N.A.
Array and export cable - supply	May be practical for some elements	Domestic manufacture of some components may potentially be practical - e.g. array cables	Nexans, Schneider Electric
Offshore substation - supply	May be practical for some elements	Manufacture of many substation componnents requires specialised expertise and equipment (e.g. large transformers) but fabrication of some components locally may be feasible, e.g. some top-side components	Brightwater Steel, Dialog Fitzroy, Eastbridge, Steel & Tube, Steelcraft
Onshore infrastructure - supply	Mostly high	Local organisations appear to have expertise needed to support developers.	Crouchers, Downer, Fletchers, High Tensile Reinforcing, MECO Engineering, Schneider Electric, Wells
survey and research database.xlsx			

4.4 Installation and connection of an offshore wind farm

In aggregate, installation and connection of wind farm components is estimated to require around 1,600 person-years of activity. The estimated share of activity among major components is shown in Figure 13.

Figure 13: Component level breakdown of installation & connection work



Source: Concept estimates based on IRENA (2018)

As with manufacturing, the single largest category is installation work for foundations which accounts for around 28% of total activity. The next largest in order are installation of turbines (22%), cabling to shore (22%) and array cable laying (20%). The balance is for substations and grid connection.

Again, it is important to note that these shares reflect the results reported in IRENA (2018) and may not necessarily apply for the Reference Scenario.

Table 12 sets out the information on work in the installation and connection phase in tabular form.

Table 12: Work required for install & connect sub-phase

Component	Person-days	Person-years	Share
Foundation	98,991	448	28%
Substation	29,300	133	8%
Cabling	77,775	352	22%
Turbine	77,084	349	22%
Array cable laying	70,602	319	20%
Grid connection	2,123	10	1%
Total	355,874	1,610	100%

Source: Concept estimates based on IRENA (2018)

4.5 Scope for domestic involvement in installation work

For each category of activity in Table 12 we have assessed the scope for involvement by people/organisations in Aotearoa New Zealand. The results are summarised below.

4.5.1 Turbine and foundation installation

The installation process begins with transporting components to a construction port. The port provides a location for storage of components, pre-assembly work, and a base for periods when weather or sea conditions are unsuitable for installation work.

Photo supplied by: Copenhagen Offshore Partners, Changfang and Xidao project, Taiwan

Foundation installation is expected to require a jack-up vessel (which may also be used for turbines) or a floating heavy lift vessel. In either case, the vessel would be fitted with installation equipment (such as a hammer and anvil system). These vessels would need to have a heavy lift capacity. For example, an individual monopile is expected to weigh 1,300 tonnes or more.[16]

There are no vessels based in Aotearoa New Zealand that meet these specialised requirements, and we expect that a suitable vessel would need to be contracted from an international provider. Similar considerations apply in the oil and gas industry, where specialised vessels or rigs have been brought into the country for offshore drilling campaigns or well work-overs.

While the main installation vessels are likely to be sourced from international providers, the turbine and foundation installation work is likely to generate demand for port- and associated marine-related services from local providers. This includes activities such as harbour-side storage, pilotage services, guard and support vessels, divers and/or remote operated vehicles for underwater inspections, and on-shore support such as accommodation and catering.

4.5.2 Array and export cable installation

Array and export cable installation may use the same vessels and equipment, but there are some differences. Array cable laying vessels need to be manoeuvrable but do not need such high carrying capacity. Export cable laying vessels are generally larger to carry the full length of an export cable.

Cables are typically buried to protect them from damage. Burial can occur when cables are laid by using a cable plough, which creates a trench in which the cable lies. Alternatively, cables can be buried later using a remote operated trenching vehicle or other equipment to create channel in which the cable will lie.

We understand there is some local capability to lay submarine power cables.[17] This suggests that local organisations may be able to lay array cables and (possibly) the larger export cables. However, more information would be needed on the cable laying requirements and potential local capabilities to make a fuller assessment.

[16] See NREL (2020).

[17] For example see www.seaworks.co.nz/sectors/submarine-cables

More generally, even if specialised vessels from outside Aotearoa New Zealand are required for cable laying, there may be opportunities for local organisations to provide support, for example with pre-lay surveys or clearance work, guard vessels etc.

4.5.3 Offshore substation installation

Installation of offshore substations raises similar issues to the installation of foundations and turbines. Our observations are therefore the same for installation of those components (see section 4.5.1).

4.5.4 Onshore facilities

Installation requirements for onshore facilities have more synergies with other existing industries in Aotearoa New Zealand. For this reason we expect local capability will be able to address most or all of the needs in relation to a shore crossing for the export cable (including horizontal drilling if required), an onshore substation, and operational facilities.

4.5.5 Summary of capabilities in installation sub-phase

Table 13 shows our summarised assessment for each major area of the installation sub-phase, including:

- the potential for domestic provision of services/products in each area
- an indicative list of the potential providers.

We need to emphasise that the list of potential providers is not exhaustive or definitive. There may be potential providers that are not listed. Conversely, listing does not guarantee that a named organisation has all of the necessary capabilities or is necessarily interested in offering the relevant services/products.

Table 13: Potential for local activity in installation sub-phase

Category	Potential for supply from sources in Aotearoa NZ	Comments	Examples of potential providers
Nacelle & rotor - install	May be practical for some elements	Specialist vessels from offshore would be needed for installation, but contractors will need a local construction port and associated support services	NZ Diving & Salvage, NZ Offshore Services, Ocean Offshore Maritime Services Ltd, PLE Rentals, Port Taranaki Ltd, Seaworks
Tower and transition piece - install	May be practical for some elements	Specialist vessels from offshore would be needed for installation, but contractors will need a local construction port and associated support services	NZ Diving & Salvage, NZ Offshore Services, Ocean Offshore Maritime Services Ltd, PLE Rentals, Port Taranaki Ltd, Seaworks
Foundation - install	May be practical for some elements	Specialist vessels from offshore would be needed for installation, but contractors will need a local construction port and associated support services	NZ Diving & Salvage, NZ Offshore Services, Ocean Offshore Maritime Services Ltd, PLE Rentals, Port Taranaki Ltd, Seaworks
Array and export cable - install	May be practical for some elements	Domestic installation of some sub-components may potentially be practical - e.g. array cables	NZ Diving & Salvage, NZ Offshore Services, Ocean Offshore Maritime Services Ltd, PLE Rentals, Port Taranaki Ltd, Seaworks
Offshore substation - install	May be practical for some elements	Specialist vessels from offshore would be needed for installation, but contractors will need a local construction port and associated support services	NZ Diving & Salvage, NZ Offshore Services, Ocean Offshore Maritime Services Ltd, PLE Rentals, Port Taranaki Ltd, Seaworks
Onshore infrastructure - install	Mostly high	Local organisations likley to have required capabilities	Crouchers, Downer, Fletchers, MECO Engineering, Schneider Electric, Wells
survey and research database.xlsx			

5 Activity in operational phase of a wind project

5.1 O&M phase lasts for 30+ years

Offshore wind farms require servicing to optimise their electricity generation output, ensure safe operation, and maintain the physical integrity of their plant and equipment. This work is commonly referred to *operations and maintenance* services or 'O&M' for short.

Wind farms have a long design life and the O&M phase is likely to run for around 30 years. Indeed, if a wind farm is repowered (which seems likely given the incentives to continue to utilise sites with high quality wind resources) the operational period would be even longer.

5.2 Location important for O&M service hubs

O&M services fall into three broad categories:

- Regular operations – this covers the ongoing running of the offshore wind farm as an electricity generator. It includes the interface with the electricity market and grid, and the planning/scheduling of all ongoing activities.
- Regular maintenance services – this covers all of the regular and ongoing maintenance such as turbine/tower inspections, oil sampling / changes; changes to UPS (uninterruptible power supply) batteries; service and inspections of wind turbine safety equipment, nacelle crane, service lift, HV system, blades, troubleshooting and preventive repairs.
- Major maintenance – this work involves more specialised equipment/personnel than regular O&M services. This type of work is expected to occur on a cycle with roughly five-year duration. Major maintenance would also include the replacement of any larger wind turbine components (such as blades) if that were to be required.

It is desirable for the hub providing regular O&M services to be located within a short distance of a wind farm it services. This is less critical for periodic heavier maintenance activities, though proximity is still beneficial.

As noted in section 1.3, the Reference Scenario for this study is based on a project in the South Taranaki Bight that is assumed to be serviced from Pātea (for regular O&M) and New Plymouth (for heavier maintenance).

Photo supplied by: Copenhagen Offshore Partners, Crew Transfer Vessel at Veja Mate Project

Development activity would be required at both ports (especially Pātea) for this scenario to be realised. Port development work is not included in the job estimates in this report.

5.3 Direct, indirect and induced work

This report distinguishes three categories of work/jobs:

- **Direct** – this is activity that is expected to be dedicated to a specific offshore wind project. For example, staff who perform regular servicing of the wind turbines in a specific project would be performing direct jobs.
- **Indirect** – this is activity for a wind farm project, but it is performed by personnel who also work on other projects or for other industries. An example would be pilots of helicopters who transfer project staff to a project's offshore turbines, but who also provide services to other organisations.
- **Induced** – this is work that is not linked directly to an offshore wind project, but which is generated by the spending power of people who are directly and indirectly employed by the project. For example, staff at a supermarket selling groceries to project personnel would be performing induced work/jobs.

These categories have been used in some other studies into offshore wind. However, we note that the line between categories can differ between studies. For example, personnel for crew transfer vessels could be considered as direct or indirect jobs, depending on whether they are dedicated to one project or provide services to multiple projects. This means that comparisons across studies need to be interpreted with care.

We have estimated the volume of work/jobs generated by an offshore wind project in terms of person-years.[18] Each person-year is equivalent to a full-time job for one person for a year. Having said that, a one-to-one translation between person-years and workers does not apply. For example, a work requirement of one person for 30 years, and a work requirement of 30 workers for one year would both generate 30 person-years of work.

We have compiled bottom-up estimates of the direct jobs for the Reference Scenario based on multiple information sources. These include:

- Studies of job impacts for offshore wind projects in other countries
- Specific information about jobs for the proposed Star of the South offshore wind farm project in Victoria
- Knowledge of operational structures for onshore wind farms in New Zealand (to the extent this is relevant).

In addition, we have drawn on a recent study prepared for Taranaki Offshore Partnership by an international consultancy specialising in providing advice on operations and asset maintenance for renewable generation projects.

We have used these sources to compile bottom-up estimates of direct jobs for the Reference Scenario project. The estimate assumes the project is run on a stand-alone basis, and it therefore includes a few roles to provide support services, such as finance and legal services. It also includes staffing for crew transfer vessels, as we assume that two vessels would be dedicated to the project.[19]

[18] In addition, we report person-days in some tables. These are computed on the assumption that there are 221 working days on average in each person-year.

[19] To ensure high levels of generator availability, we have assumed an operating structure with two crew transfer vessels and three personnel per boat. To provide cover for planned and unplanned leave, training etc. for crews, it is necessary to have more crews than boats. The additional cover requirement is expected to be around 0.5 of a crew, but crew increments must be whole numbers. We have assumed a three-crew structure meaning a total CTV complement of nine personnel.

In aggregate, we estimate that around 70 full time equivalents (FTE) direct jobs would be generated for a 1,000 MW wind farm. The corresponding estimate for the second stage of the project (with 2,000 MW in total capacity) is 120 FTE jobs. The larger project requires more personnel to undertake the operational and maintenance functions, but other support roles are not expected to scale proportionally with wind farm capacity (e.g. the finance roles).

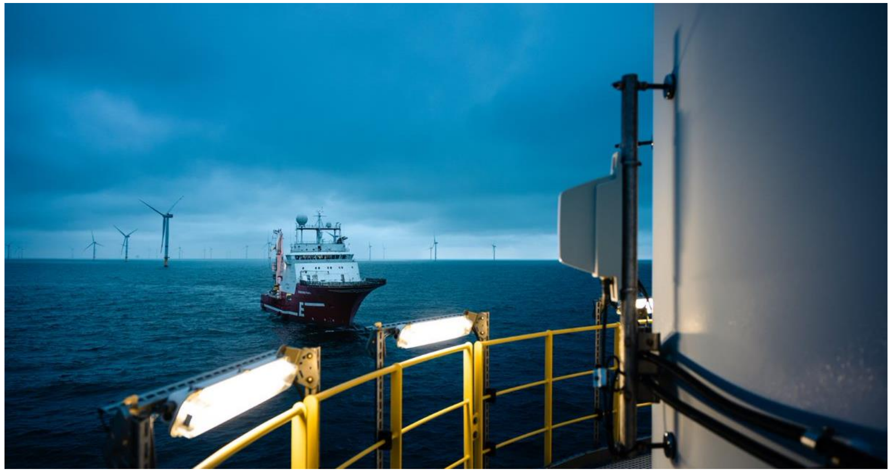
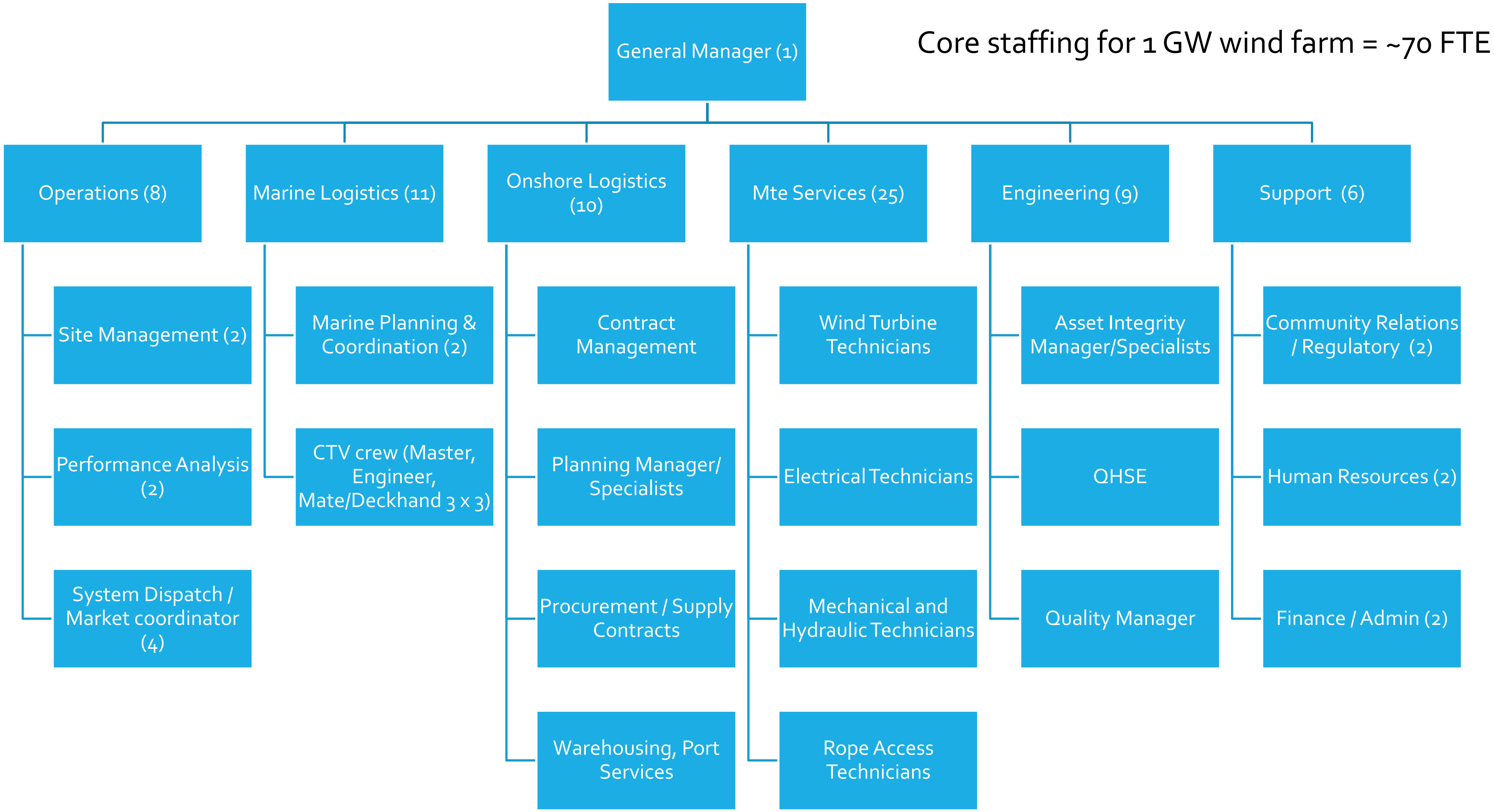


Photo supplied by: Copenhagen Offshore Partners, Veja Mate Project

The functional breakdown of the various roles for the 1,000 MW wind farm is set out in Figure 14. Note that this is not an organisation chart in the traditional sense and does not indicate reporting hierarchies. Rather it is intended to provide information on the types of roles needed for core O&M services and their broad functional areas.

The numbers shown on the chart assume that each of the roles is performed by a full-time employee. We note that job-sharing might occur for some roles. That would increase notional headcount but not the count in full time equivalent (FTE) terms.

Figure 14: Core O&M services – estimated staffing for 1,000 MW Reference Scenario project



Source: Concept estimates based on analysis of multiple data sources. Figures and positions are indicative. Some roles could be trainees/apprentices.

5.3.1 Further information on the direct O&M jobs

A position description for each direct role is set out in the accompanying *Jobs Guide*. These descriptions draw heavily on the equivalent document published for the proposed Star of the South project in Australia.

Figure 15 shows an example of a position description, in this case for a wind turbine technician.

Figure 15: Example of position description for core roles

Wind Turbine Technician

Location	Offshore
Work environment	Site
Work Area	Wind turbine generators
Typical employer	Lead contractor or subcontractor
Applicable project phase	Operations

Tasks and Responsibilities

A Wind Turbine Technician forms an integral part of the operations and maintenance team and is typically required to complete routine maintenance checks, diagnose faults, and ensure the turbines are running at peak capacity. In addition to this, Wind Turbine Technicians are often required to assist in large component replacements and troubleshoot issues.

Example Competencies

Qualifications	• Trade qualification, electrical, mechanical, or equivalent skill set from another heavy industry highly desirable • Dogging and Rigging certifications* • First Aid Level 2 (NZQA Standard 6400) • IRATA rope access certification desirable • Current GWO Basic Safety Training (BST) – Offshore Certification • Current HUET (1-day course) • Current OGUK Medical and Chester Step Test desirable • E-learning training for service lift model (this training is desirable but will be dependent on the turbines installed
Experience	• Experience in a highly disciplined industry such as aviation, military, automotive, power, mining or oil and gas • Experience in offshore or onshore wind highly desirable but not essential • Experience in a working at heights role highly regarded
Skills and knowledge	• Mechanical skills, with the ability to repair mechanical, hydraulic, braking, and electrical systems of the wind turbines • Ability to document and report on all work activities including repairs, testing, and inspections • Troubleshooting skills with the ability to diagnose faults and problem solve
Physical Requirements	• Physical capability to work at heights, work and crawl in confined spaces and lift heavy items • Ability to work offshore on a regular rotation roster • Ability to pass OGUK Medical and Chester Step Test
Personal Attributes	• Strong communication skills and interpersonal skills • Safety focused, with the ability to promote and adhere to a safety-first work culture • Ability to work with various contractor and subcontractor groups including different cultures / nationalities

The position descriptions provide information on where each role is located (onshore or offshore), the potential employer (owner, lead contractor, sub-contractor), main tasks and responsibilities, and examples of competencies required for each role.

The descriptions also indicate the phases of a project life cycle for which each role is needed. The descriptions have been provided to help provide a more concrete sense of the types of roles that the O&M phase of an offshore wind farms would generate.

The Jobs Guide also includes a summary of the likely qualifications/entry pathways for each position. These range between secondary school through to trade or tertiary qualifications. A summary of this information is provided in Figure 16.

Figure 16: Direct jobs and indicative qualifications

	Plan	Build	O&M	Trade	Marine	On-the-job	Secondary school	Tertiary
Marine Coordinator		■	■		●			
Finance Manager / Specialist		■	■				●	●
Site Manager		■	■	●				●
Apprentice Mechanical / Hydraulics Technician		■	■			●	●	
Apprentice Electrician		■	■			●	●	
Mechanical / Hydraulics Technician		■	■	●		●		
Electrical Technician / Supervisor		■	■	●		●		
Remote Operated Vehicle Technician		■	■	●		●		
QHSE Manager		■	■					●
Control Room Technician		■	■	●		●		●
Site Administrator		■	■			●	●	
Painter / Rope Access Technician		■	■	●				
Warehouse Coordinator		■	■			●	●	
Wind Yield Performance Analyst			■					●
Deckhand / Mate – Crew Transfer Vessel			■		●			
Master – Crew Transfer Vessel			■		●			
Engineer – Crew Transfer Vessel			■		●			
Asset Integrity Manager / Specialist			■	●				●
Wind Turbine Technician			■	●		●		
Finance Manager / Specialist			■				●	●
General Manager			■	●				●
Contracts and Commercial Manager			■					●
Procurement Manager / Specialist			■	●			●	●
Planning Manager / Specialist			■	●				●
Human Resources Manager / Specialist			■	●				●
Finance Manager / Specialist			■				●	●
Regulatory Compliance and Community			■			●		●

5.4 Indirect jobs/work in operational phase

As discussed in section 5.3, indirect jobs refer to positions needed for an offshore wind farm, but which are not expected to be dedicated to one project. Examples of jobs/work in this category are listed in Table 14.

Table 14: Examples of indirect O&M jobs/work

Job service category (not exhaustive)	Examples
Aviation, port and offshore services	Helicopter, diving, remote operated vehicles, harbour, wharfage, pilotage, navigation services, metocean forecasts, emergency services etc
Consumables, general services	IT, comms, corrosion control products, fuels, lubricants, power, personal protective equipment provision and testing etc
Environmental, inspection, certification	Certification/testing of cranes, vehicles, crew transfer vessels, tools and equipment etc, ensure compliance with consents etc
Facilities management & support	Maintenance for onshore structures/facilities, monitoring of operational sites, fire detection, cleaning, catering, vehicle and vessel maintenance, waste management services etc
Human resources	Recruitment and training, eg GWO courses
Land transport and warehousing	Freight to operational sites, vehicle hire, oversized loads, storage etc
Major maintenance	Periodic refurbishment/replacement of major components for turbines or plant

To estimate the volume of indirect work associated with a 1,000 MW project, we have used two approaches. The first draws on the bottom-up study carried out for Taranaki Offshore Partnership by the international operations and asset management specialist noted earlier. That study indicated a high-level estimate of around 43 roles engaged to provide indirect services.[20] This equates to a ratio of direct to indirect jobs of about 0.6.

The second approach was to estimate a ratio of direct to indirect jobs in from published international studies and apply that to the direct job estimates noted in section 5.5.1. Among the studies we identified, there was a wide range in the direct to indirect jobs ratio.[21] In part this is likely to reflect differences across studies in the proportion of services that are shared across projects (noting this affects whether a role is classified as direct or indirect). Higher ratios are expected in studies where offshore wind was well-established and there was more extensive sharing of contracted services (and therefore more shared roles).

We do not expect those conditions to be applicable in New Zealand, given the early stage of development of offshore wind in this country. We therefore focused on the studies which report ratios that are below the

[20] The report actually had a slightly higher figure for indirect jobs because excluded staff for crew transfer vessels on the assumption these would be externally contracted on a shared basis. We have instead assumed crew transfer vessel personnel will be dedicated to the project. They are therefore counted as direct jobs.

[21] See Appendix B: for more information.

median ratio level. Among these eight studies the mean reported indirect to direct jobs ratio was 1.0.

In the light of the above, we have adopted a range of 0.6 to 1.0 as the expected ratio of direct to indirect jobs. We expect these ratios would apply for the 1,000 MW and 2,000 MW cases in the Reference Scenario.

For the Reference Scenario, this implies approximately 43 to 70 FTEs in indirect jobs for the 1,000 MW wind farm, and 73 to 120 FTEs for the 2,000 MW wind farm.

5.5 Scope for domestic involvement in operational work

For each major type of activity in the operational phase, we have assessed the scope for involvement by people/organisations in Aotearoa New Zealand. The results are summarised below.

5.5.1 Direct O&M positions

All of the direct O&M roles are expected to be required for the 30+ year operational life of the project. For this reason, we expect all of these roles to be performed by personnel in the region where the project is located. The roles could be employed by a project owner, a lead contractor (engaged by the owner) or a sub-contractor (engaged by a lead contractor).

In this context, we note that it is common for manufacturers of wind turbines to be responsible for maintenance services relating to the turbines themselves during the initial warranty period. The exact duration and scope of warranties would be a matter for negotiation between project developers and manufacturers, but we understand five-to-ten year initial warranty periods are not uncommon for offshore turbines.

Notwithstanding that an international manufacturer may be responsible for turbine maintenance services in the warranty period, we expect most regular maintenance roles to be filled by locally engaged staff. Such staff could be employed by an original equipment manufacturer or via a subcontractor. We expect the majority of personnel to be locally engaged because of the higher costs and logistical issues that a manufacturer would face if it sought to fill such roles using offshore-based workers on a fly-in/fly-out basis.

Experience in New Zealand with onshore wind and other generation types supports the view that most personnel undertaking regular and ongoing maintenance work will be locally engaged. For example, at the time of writing both of the major suppliers of onshore turbines in Aotearoa New Zealand (Siemens Gamesa and Vestas) were advertising to fill wind turbine technician positions with local staff.[22]

5.5.2 Indirect O&M positions

We expect much of the indirect O&M work listed in Table 14 could be undertaken by locally engaged personnel. This is because it requires skills and expertise that is already available and in use. In particular, there is significant overlap in the skills required for offshore wind and the oil and gas industry, such as in marine services.

The main area where overseas support may be required is major maintenance activity. Some of this is expected to require expertise/equipment that would be needed infrequently and could therefore be uneconomic to maintain in Aotearoa New Zealand. Major maintenance also includes the replacement of any major components –

[22] See https://careers.vestas.com/job/Palmerston-North-Service-Technician-NZ-MWT/826636801/ and https://www.linkedin.com/jobs/view/service-technician-harapaki-wind-farm-at-siemens-gamesa-3578403713/?originalSubdomain=nz (both downloaded 4 June 2023).

such as blades or generator units. Specialised marine cranes would be needed for this type of work which are unlikely to be available domestically.

Another area where specialised skills may be needed is cable repairs and/or retrenching. We understand cable repairs are not uncommon with offshore wind farms. As noted in section 4.5.2, it appears that some capability to undertake work on submarine cables does currently exist in Aotearoa New Zealand. For this reason, this type of major maintenance activity may be feasible using local resources. However, further information would be needed to make a definitive assessment and that lies outside the scope of this report.

5.5.3 Summary of capabilities in operational phase

Table 15 shows our summarised assessment for each major area of the operational phase, including:

- the potential for domestic provision of services/products in each area
- an indicative list of the potential providers.

We need to emphasise that the list of potential providers is not exhaustive or definitive. There may be potential providers that are not listed. Conversely, listing does not guarantee that a named organisation has all of the necessary capabilities or is necessarily interested in offering the relevant services/products.

Table 15: Potential for local activity in operational phase

	Category	Potential for supply from sources in Aotearoa NZ	Comments	Examples of potential providers
Direct	Core operation	High	Covers interface with electricity market, forecasting, planning, interactions with local stakeholders, customers, suppliers etc.	Expect local workforce to perform most of the work - either for project owner, turbine supplier or sub-contractor
	Core maintenance	High	Covers regular and troubleshooting maintenance activities, condition monitoring, etc.	Expect local workforce to perform most of the work - either for project owner, turbine supplier or sub-contractor
Indirect	Aviation, port & offshore services	High	Harbour, wharfage, pilotage services, navigation, metocean forecasts. Significant marine support needed for offshore O&M activities	Advanced Flight, GCH Aviation, Kingston Offshore, Midwest Helicopters, New Plymouth Underwater, NZ Offshore Services, Ocean Infinity, PHI International NZ, Seaworks, Southern Express, Underwater Solutions
	Consumables, general services	High	Expect local organisations to be able to supply most general services/products - e.g. IT, lubricants, safety equipment	AB Industries, Blackwoods, Cleanline Tasman, Duramach, NZ Safety, One, Online Communications, Resene, Sika, Spark
	Inspection, certification and environmental monitoring	High	Expect local organisations to be able to supply most services	Ariki Marine, Bureau Veritas, Dynamic Ratings, Elcon, SGS
	Facilities management, catering and accom, vehicle & CTV maintenance	High	Expect local organisations to be able to supply most services	Diesel Marine, local accom and catering organisations, OCS, Serco, TIS, West Coast Marine
	Human resources	High	Covers recruitment and training, e.g. GWO courses. Expect local organisations to provide most services, supplemented by periodic overseas support for specialised skills	Atlantic 21, Atlas Professionals, Haines Attract, NES Global, Te Pukenga, Vertical Horizonz, Wood Training
	Major maintenance services - turbines	Mixed	Covers general maintenance support - to supplement the dedicated workforce. Likely to need to draw on international suppliers for periodic (~5 years) heavy maintenance.	Dynamech, ISS, SRG Global Asset Services NZ, turbine suppliers
	Major maintenance services - balance of plant	Mixed	Local organisations may have capability to service foundations (e.g. corrosion mngt), and possibly some aspects of cable and substation repairs. However, overseas support likely to be required for heavy maintenance work such as transformer replacement	Electrix, Electronet, Northpower, Pringle Beleski & Assoc, Seaworks, Ventia, turbine suppliers
	Transport and warehousing	High	Transportation of equipment (including oversized loads) by road, and storage services. Expect local organisations to perform most of this work	Agtrans, ISO Ltd, Smith Crane Services, Symons Group, Tito Transport

survey and research database.xlsx

5.6 Induced jobs in operational phase

All of the preceding discussion focussed on direct and indirect jobs/work in the operational phase, i.e. personnel working for the wind project as employees or contractors.

As discussed in section 5.3 induced jobs are roles generated by the spending of people employed in the direct and indirect O&M jobs. For example, it would include a person working in supermarket who sells groceries to someone employed by the wind project (directly or via an O&M service provider). Similarly, builders and contractors who repair houses occupied by workers employed to provide O&M services to the wind project would fall into the induced job category.[23]

For this study is not practical to estimate the induced jobs using a bottom-up approach. Instead, we have used overseas studies of offshore wind to estimate the ratio of induced jobs to jobs in direct and indirect roles. The logic for focussing on this ratio is that induced jobs are likely to be strongly associated with the level of spending by the workers undertaking direct and indirect jobs, which in turn is closely linked to number of such workers. The ratio reported across different overseas studies ranged between 0.22 and 0.70, with a median value of 0.52.

For this study, we have adopted a lower range value of 0.29 (based on the 20th percentile of values in overseas studies) and a higher value of 0.63 (based on the 80th percentile value).[24] We have applied these same ratios for the 1,000 MW and 2,000 MW cases in the Reference Scenario.

Applying these ratios yields estimates of 32 to 89 FTE induced jobs for a 1,000 MW wind farm project, and 55 to 152 FTE induced jobs for the 2,000 MW wind farm project.

Finally, all of the induced jobs are expected to be undertaken by people in the region where the project is located.

Photo supplied by: Copenhagen Offshore Partners, Veja Mate Project

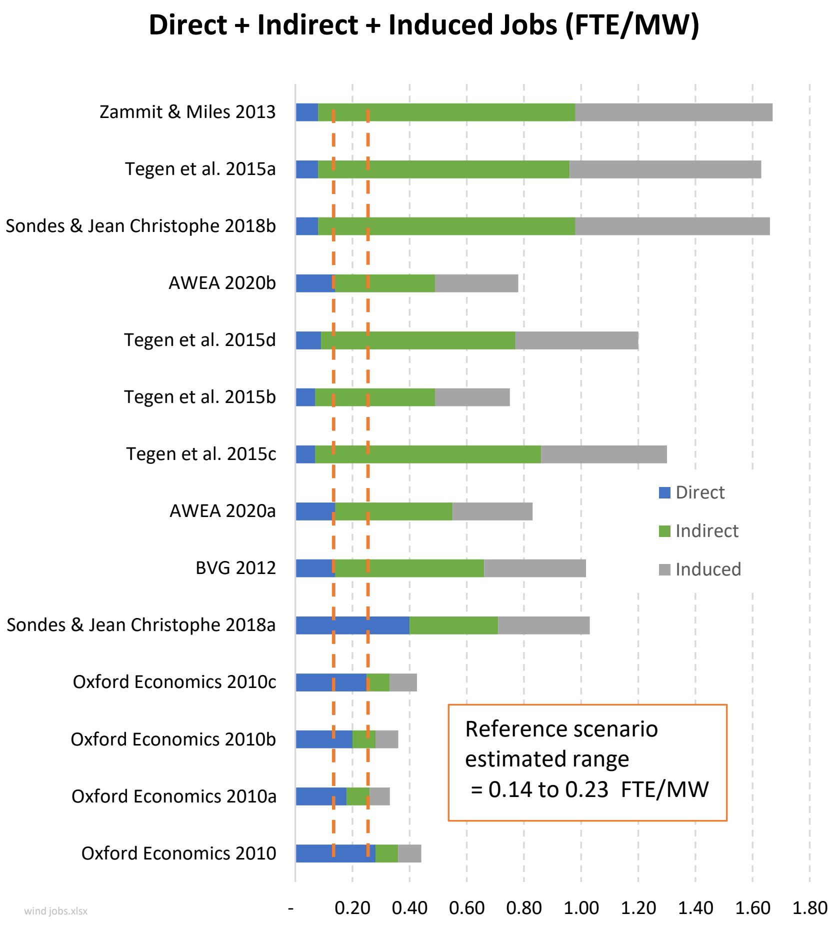
5.7 Cross-check of O&M job estimates with other studies

To cross-check our O&M job estimates we compared them to figures in overseas studies. Because of the differences across studies, the comparison was done at an aggregate jobs level and converted into FTE jobs per MW of installed wind farm capacity.

[23] Obviously for both the grocery worker and builders, some proportion of their job would be counted as induced by the presence of the wind project.

[24] See Appendix B: for more information.

Figure 17: Comparison of job estimates across studies (FTE/MW)



Source: Concept analysis of overseas studies. See appendix for more information.

Figure 17 shows the results of this comparison in graphical form. The bars show results for individual studies/projects. The orange dotted lines show Concept's estimates for a 1,000 MW wind farm expressed in FTE/MW terms. Key observations from the chart are:

- There is a fairly wide range of values reported in international studies, both for total FTE/MW and in the breakdown of those totals between direct, indirect and induced jobs.
- Concept's estimated FTE/MW range is at the bottom end of the range of values reported in international studies.

We think the wide range of values reported in international studies partly reflects differences in definitions and methodology across studies. It will also likely reflect physical differences in the underlying projects covered by each study.

Photo supplied by: Copenhagen Offshore Partners, offshore substation at Veja Mate Project

In particular, the number of O&M jobs is likely to be more closely linked to the number of turbines in a project than the wind farm's overall MW capacity. As technology has improved and turbines have grown in MW capacity, this will have altered the number of FTEs required and may contribute to the spread of results. Another difference may be the variation in distances between service ports and wind farms, noting that greater distances will typically increase FTE requirements due to longer travel times.

Overall, the international data suggests that the Concept estimates may be on the conservative side (i.e. more jobs may be generated in practice than indicated by Concept's estimates).

5.8 Overall jobs generated in the operational phase

Table 16 provides a breakdown of Concept's FTE estimates of jobs created for each category (direct, indirect, induced). It shows that a 1,000 MW offshore wind project is expected to generate between approximately 150 and 230 full time equivalent jobs in its operational phase.

Table 16: FTE jobs in operational phase for 1,000 MW wind project

FTE equivalents in each year of operation				
1 GW Offshore Wind Project	**Direct**	**Indirect**	**Induced**	**Total**
Concept - lower estimate	70	43	32	145
Concept - central estimate	*70*	*56*	*60*	*187*
Concept - higher estimate	70	70	89	229
Person years of work over project life				
1 GW Offshore Wind Project	**Direct**	**Indirect**	**Induced**	**Total**
Concept - lower estimate	2,170	1,318	1,001	4,488
Concept - central estimate	*2,170*	*1,744*	*1,873*	*5,787*
Concept - higher estimate	2,170	2,170	2,746	7,086
wind jobs.xlsx				

Source: Concept analysis

The table also shows the same results expressed in terms of person-years of work. Arguably, this is the more meaningful yardstick as the O&M phase is expected to run for 30+ years. We estimate that a 1,000 MW project would generate around 4,500 to 7,100 person-years of work during its operational lifespan.

As noted in section 1.3 the Reference Case is based on an initial project size of 1,000 MW which is subsequently expanded to 2,000 MW. Table 17 shows the results for the case of a 2,000 MW offshore wind farm.

A 2,000 MW offshore wind project is expected to generate between approximately 250 and 390 full time equivalent jobs in its operational phase. This equates to around 7,700 to 12,100 person-years of work during its operational lifespan.

Table 17: Person-years of work over project life span

FTE equivalents in each year of operation				
2 GW Offshore Wind Project	**Direct**	**Indirect**	**Induced**	**Total**
Concept - lower estimate	120	73	55	248
Concept - central estimate	*120*	*96*	*104*	*320*
Concept - higher estimate	120	120	152	392
Person years of work over project life				
2 GW Offshore Wind Project	**Direct**	**Indirect**	**Induced**	**Total**
Concept - lower estimate	3,720	2,259	1,716	7,694
Concept - central estimate	*3,720*	*2,989*	*3,211*	*9,921*
Concept - higher estimate	3,720	3,720	4,707	12,147
wind jobs.xlsx				

Source: Concept analysis

6 Areas for possible future research

This report focuses on two questions:

1. What activities are needed to plan, build and operate an offshore wind farm?
2. What capabilities exist in Aotearoa New Zealand to undertake the activities set out in item 1?

A distinct but related question is: *what actions could be taken to help Aotearoa New Zealand to maximise the opportunities from development of an offshore wind industry?*

While this question is not the focus of this study, in this chapter we offer some high-level suggestions for further work.

6.1 Help local supply chains to prepare and be efficient

Organisations in Aotearoa New Zealand will be better placed to supply products/services to an offshore wind industry if they have sufficient notice of future opportunities and can plan ahead. Advance notice will be particularly relevant in the early stages of the industry when offshore wind is completely new to the country.

Prospective developers (and/or government agencies) can help local organisations to prepare by providing information about likely future needs and the timing of projects. This would help local suppliers to assess the scale of opportunities, invest in training and/or equipment where it makes sense, and gather information needed to demonstrate their capabilities.

This study can be viewed as an initial step in this pathway because it provides potential suppliers with some high-level information on the products/services that developers would need to build and support an offshore wind industry.

However, most local suppliers are likely to need more specific information to properly assess the opportunities and prepare themselves.

Potential examples that could fall into the category of sharing more specific information are transition piece sub-components and array cables as discussed in sections 4.3.2 and 4.3.4.

6.2 Facilitate collaboration between local and overseas companies

As discussed earlier in this report, a sizeable portion of the wind turbine manufacturing and installation work is likely to be undertaken by overseas organisations given the specialised skills/equipment required. However, even where overseas suppliers are needed there may be opportunities for local organisations to collaborate, especially for installation work.

A factor which could hinder such collaboration is offshore suppliers' lack of familiarity with local organisations and their capabilities. In effect, this is the mirror image of the challenge described in section 6.1.

To address this issue, we see merit in developing and maintaining a database of local organisations who could supply relevant services/products into the offshore wind sector. The results from the survey conducted as part of this report could serve as a starting point for such a database.

To have ongoing benefit, it would need to be updated over time. Possible candidates to maintain a database include wind developers, umbrella bodies (such as the New Zealand Wind Energy Association or a similar body), local business or development groups (such as Business New

Zealand, Taranaki Chamber of Commerce, or Venture Taranaki) or a government supported agency (such as Ara Ake or New Zealand Trade and Enterprise).

6.3 Help workers to develop relevant skills

Many of the roles created by an offshore wind industry would require skilled personnel. An indication of the qualifications required for the operational phase staff is set out in Table 18 (see the accompanying Jobs Guide for more information).

Table 18: Indicative list of qualifications and roles

Desirable qualifications	Roles
Occupational diving COC (Certificate of Competence) and ADAS	Divers
NZQA Standard 6400 (First aid level 2)	Multiple operational roles
Diving medical clearance DHMS	Divers
Basic Offshore Safety Induction and Emergency Training (BOSIET)	Multiple operational roles
Maritime NZ Medical Clearance	Crew transfer vessel staff
Certificate of Safety Training (full course) - STCW Reg IV/1	Multiple operational roles
Chester Step Test	Multiple operational roles
Confined Space Entry Certificate	Wind turbine technicians
Dogging and Rigging Certifications	Wind turbine technicians
NZ Full Drivers License	Most roles
Elevated Work Platform (EWP) certification	Wind turbine technicians
Global Wind Organisation (GWO) Basic Safety Training (BST)	Wind turbine technicians
Global Wind Organisation Blade Repair Training Certificate	Wind turbine technicians
Global Wind Organisation (GWO) Basic Technical Training	Wind turbine technicians
Helicopter Underwater Escape Training (HUET)	Offshore staff
High Voltage certifications	Wind turbine technicians
Inshore / domestic maritime qualifications	Crew transfer vessel staff
IRATA Rope Access Certification	Wind turbine technicians
ISO 9001, ISO 14001 and ISO 45001 Internal Auditor Training	QHSE staff
Minimum CIP -2 Certified Coating Inspector	Wind turbine technicians
Permit to Work Training	Wind turbine technicians
New Zealand GMDSS radio operator certificate	Site administrators
Wind farm maintenance Certificate level 4	Wind turbine technicians
Trade Certificates	Wind turbine technicians
Welding Certificate	Wind turbine technicians
Working at Heights certificate	Wind turbine technicians

One important potential source for skilled workers is the oil and gas industry because of the significant cross-over between the skills required in the two industries. For example, a 2019 study found that more than 85% of occupational roles in the oil and gas industry had some skills overlap with offshore wind.[25] Another potential source of skilled workers is the *onshore* wind industry. In both cases, to the extent that any additional specific offshore wind training is required for these types of workers, it could possibly be provided on-the-job or by micro-credential courses.

More generally, it will be important to ensure that training is available for people looking to enter the offshore wind industry. The Jobs Guide lists potential qualification requirements and potential training providers, but it is only indicative. For example, it does not include any information on the training that offshore wind operators or turbine maintenance firms may be able to offer. This could include initiatives such as on-the-job training, apprenticeships, sponsored study, and overseas training arranged via affiliates or partners.

We think there would be merit in developing a more comprehensive inventory of the skills/qualifications required by people working in an offshore wind industry, and the organisations that could provide training to meet those requirements.

6.4 Address hurdles faced by Māori

Representatives of iwi and other Māori organisations contacted as part of this study were keenly interested in the opportunities that could be generated by an offshore wind industry in Aotearoa New Zealand.

The areas of interest included the potential supply of services/products to wind projects by Māori-owned or affiliated organisations, through to employment opportunities in the operational phase for rangatahi (young people).

Of course, Māori are not unique in the desire to capitalise on opportunities from development of an offshore wind industry. However, as noted by many stakeholders, Māori organisations and individuals often face additional hurdles to participation when compared to the general population. Impediments can include factors such as poor access to information networks, perceived capacity gaps, and/or short organisational track-records. The proposals set out in sections 6.1 to 6.3 are unlikely to directly address these hurdles.

We are aware of some existing initiatives/groups working to enhance the capacity of Māori organisations to benefit from business opportunities more generally. These include:

- Amotai – a national organisation working with government, corporate and Iwi organisations to facilitate procurement opportunities and foster connections with Māori and Pasifika businesses[26]
- He Toronga Pakihi ki Taranaki – a Māori Business Network in Taranaki[27]
- Kōtuiā te hono – the Māori Reference Group for the Construction Sector Accord. This group aims to drive delivery and advice on how the Accord can uplift the Māori construction economy.[28]

[25] For 18% of occupations there was insufficient data to make an assessment. See Offshore Wind Energy Australia, July 2021, Blue Economy Cooperative Research Centre. (Friends of the Earth; Global Witness and Greener Jobs Alliance, 2019).

[26] See https://amotai.nz/about

[27] See https://htpkt.maori.nz/

[28] See www.constructionaccord.nz/news/news-stories/new-operating-model-for-construction-accord/

- Whāriki – an organisation committed to developing the Māori economy.[29]

We are not in a position to assess whether these initiatives or groups would enable Māori to fully capitalise on the opportunities presented by an offshore wind industry. However, given the importance of this issue, we suggest that it warrants further consideration.

6.5 Local content requirements

Some countries require offshore wind developments to meet a 'local content requirement', for example as a condition of being awarded development consents.

A recent World Bank report on offshore wind included a section on the international experience with local content requirements.[30] The study noted that some countries have adopted strict minimum local content levels as part of the project consenting process.

For example, Taiwan's authorities initially imposed strict local content requirements in some areas. This led to the establishment of local supply in those areas, but this appears to have imposed cost penalty and it is unclear if local supply will be sustained without ongoing support. France appears to have followed a parallel approach with similar results.

At the other end of the spectrum the World Bank noted that the Netherlands awards project rights based solely on costs and feasibility. The Dutch government claimed that a combination of competition and lack of local content requirements has produced significant cost savings.

[29] See www.whariki.co.nz/about-us

[30] See World Bank (2021b), p.24.

The United Kingdom appears to have adopted an intermediate approach, with a sector target for 2030 agreed with the industry, but no formal local content requirements on individual projects.

Overall, the World Bank concluded that "experience in markets, such as in France and Taiwan, has shown that local content requirements (LCRs) tend to reduce competition, increase cost and risk, and slow market development".[31] The World Bank suggested that measures to strengthen the local supply chain were a better alternative to mandatory local content rules.

We have not examined the merits of the alternative approaches in detail. However, the points made by the World Bank are worth considering, especially as local content requirements seem to have had mixed results even in advanced manufacturing economies such as Taiwan and France.

[31] Ibid, p.12.

References

American Wind Energy Association (2020). *U.S. Offshore Wind Power Economic Impact Assessment.* Cited in Gaido (2021).

Electricity Authority Market Development Advisory Group 2022). *Price discovery under 100% renewable electricity supply Issues Discussion Paper.* Report published by the New Zealand Electricity Authority.

BVG Associates Limited (2012). *UK content analysis of Robin Rigg Offshore Wind Farm operations and maintenance.* Cited in Gaido (2021).

Gaido, German Perez (2021). *Offshore wind in Taranaki Assessment of potential regional long-term employment and expenditures,* Research Report submitted for Masters Thesis at The University of Auckland.

International Renewable Energy Agency (2018). *Renewable Energy Benefits: Leveraging Local Capacity for Offshore Wind,* IRENA, Abu Dhabi

International Energy Agency (2019). *Offshore Wind Outlook 2019.* Wind Energy Outlook Special Report. https://www.iea.org/reports/wind-electricity

International Energy Agency (2021), *Renewables 2021 Analysis and forecast to 2026.* https://www.iea.org/reports/wind-electricity

Ministry of Business, Innovation and Employment (2022). *Enabling Investment in Offshore Renewable Energy Discussion Document.* https://www.mbie.govt.nz/dmsdocument/25828-enabling-investment-in-offshore-renewable-energy

National Renewable Energy Laboratory (2020). *IEA Wind TCP Task 37 Definition of the IEA Wind 15-Megawatt Offshore Reference Wind Turbine Technical Report.* https://www.nrel.gov/docs/fy20osti/75698.pdf

Oxford Economics. (2010). *Analysis of the Employment Effects of the Operation and Maintenance of Offshore Wind Parks in the UK.* https://www.oxfordeconomics.com/publication/open/24009 Cited in Gaido (2021).

Sondès, K., & Jean Christophe, M. (2018). *Can Offshore Wind Energy Be a Lever for Job Creation in France? Some Insights from a Local Case Study. Environmental Modeling and Assessment,* 23(3), 203–227. https://doi.org/10.1007/s10666-017-9580-4 Cited in Gaido (2021).

Tegen, S., Keyser, D., Flores-Espino, F., Miles, J., Zammit, D., & Loomis, D. (2015). *Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios Great Lakes Wind Network.* www.nrel.gov/publications. Cited in Gaido (2021).

Taranaki Offshore Partnership (2023). Background material and graphical information, https://taranakioffshorewind.co.nz/about/

World Bank (2021a). *Offshore Wind Roadmap for Vietnam,* Offshore Wind Development Program report, Washington DC.

World Bank Group (2021b). *Key Factors for Successful Development of Offshore Wind in Emerging Markets*. ESMAP, World Bank, Washington, DC.

Zammit, D., & Miles, J. (2013). *Potential economic impacts from offshore wind in the United States - The Southeast Region.* Cited in Gaido (2021).

Appendix A: Top-down estimates for jobs

As discussed in section 1.4 we have prepared bottom-up estimates of jobs for the O&M phase of an offshore wind project. For other phases (i.e. planning, building and decommissioning/repowering) we have compiled top-down estimates based on a review of international sources.

The most useful source we have identified for the latter purpose is the *Renewable Energy Benefits*[32] study published by the International Renewable Energy Agency (IRENA) in 2018.

IRENA's study was compiled using information gathered through international surveys and interviews with offshore wind industry experts and a review of published research. Data was sourced from project developers, component manufacturers, service providers, energy authorities and national and global associations for wind and renewable energy.

We consider that the IRENA report is among the most useful for our work because it:

- Focuses exclusively on offshore wind (some other studies mix data for onshore and offshore projects)
- Was completed relatively recently whereas some other studies are becoming quite dated. Recent data is important because the industry has evolved significantly since the initial projects in the 1990s and early 2000s.
- Captures a cross-section of international experience, not just data about European conditions. This is important as Europe has a well-developed ecosystem for offshore wind farm development, whereas New Zealand is at a much earlier stage in the industry evolution.

We have also compared IRENA's top-down projections for O&M jobs with our own bottom-up estimates for that category of activity. The IRENA estimates align reasonably well with our data after making an adjustment to account for the difference in wind turbine size.

The above factors give us some confidence that the IRENA information provides reasonable high-level guidance regarding job opportunities for various stages in the development of offshore wind projects.

We also considered whether to rely mainly on the IRENA study or try to build-up a composite based on multiple studies. We concluded that it is better to use the IRENA report because applies a common methodology and definitions across all aspects of its analysis. In contrast, a composite approach has the significant risk of mixing apples and oranges.

Having made these points, we have made one significant adjustment to the results in the IRENA (2018). That study set out estimates for a notional 500 MW offshore wind farm development – i.e. 50% of the size of the development in the Reference Scenario.

It is tempting to simply double the work/job estimates in the IRENA report to generate estimates for the Reference Scenario. However, we think that

[32] IRENA (2018), *Renewable Energy Benefits: Leveraging Local Capacity for Offshore Wind,* IRENA, Abu Dhabi*:* This is henceforth referred to as the IRENA 2018 report.

would likely over-estimate the jobs/work because activity is not necessarily proportional to the MW capacity of an offshore wind project in all areas. For example, the activity required to obtain consents, electricity sale agreements and supplier contracts will be affected by the complexity of a project, and not just its MW capacity. Similarly, some activities (e.g. foundation design work) will be more closely related to the number of turbines than overall wind farm MW capacity.[33] Given these sorts of factors, we treat a doubling of the IRENA figures as an upper estimate for jobs/work associated with a 1,000 MW project.

At the other end of the scale, we treat the IRENA estimate without any adjustments as the lower estimate. This implicitly assumes that activity does not change between a 500 MW and 1,000 MW project. This is likely to be an under-estimate. However, we note that the IRENA study appears to assume 8 MW turbines[34] implying around 63 turbines. That is very similar to the number of turbines assumed in stage 1 of the Reference Scenario. To the extent that the number of turbines is a key driver of work/jobs, the raw IRENA figures would not necessarily be an under-estimate.

Our central estimate is the average of the upper and lower estimates.

The IRENA-based estimates have been adopted for all stages of a wind farm project except for O&M activities. For that phase we adopted bottom-up estimates as described in Chapter 5.

A summary of the lower-, mid- and upper-estimates is set out in Table 19.

Table 19: Work/job estimates for phases of 1,000 MW project

Person-years	Lower estimate	Mid-estimate	Higher estimate
Planning	108	162	216
Procure	33	50	66
Manufacture	5,667	8,501	11,335
Install & connect	1,074	1,610	2,147
Operate and maintain	3,488	3,914	4,340
Decommission	441	661	882
Total	10,810	14,898	18,986
windjobs.xlsx			

Source: Concept estimates

[33] Larger turbines would require more substantial foundations but there would be fewer of them to design.

[34] There is a reference to a 500 MW project using 8 MW turbines in Figure 2.4 of IRENA (2018) which provides a cost breakdown. The next section in the report which provides a breakdown of jobs also refers to a 500 MW project but does not indicate turbine size in MW/unit.

Appendix B: Direct, indirect and induced job estimates for operational phase

Source	Direct	Indirect	Direct + indirect	Induced	Total	Ratio of indirect to direct	Ratio of induced to direct+indirect
Oxford Economics 2010	0.28	0.08	0.36	0.08	0.44	29%	22%
Oxford Economics 2010c	0.25	0.08	0.33	0.10	0.43	32%	29%
Oxford Economics 2010b	0.20	0.08	0.28	0.08	0.36	40%	29%
Oxford Economics 2010a	0.18	0.08	0.26	0.07	0.33	44%	27%
Konig et al. 2016	0.11	0.06	0.17	-	0.17	52%	
Sondes & Jean Christophe 2018a	0.40	0.31	0.71	0.32	1.03	78%	45%
Glasson et al. 2020	0.15	0.37	0.52	-	0.52	247%	
AWEA 2020b	0.14	0.35	0.49	0.29	0.78	250%	59%
AWEA 2020a	0.14	0.41	0.55	0.28	0.83	293%	51%
BVG 2012	0.14	0.52	0.66	0.36	1.02	371%	54%
Tegen et al. 2015b	0.07	0.42	0.49	0.26	0.75	600%	53%
Tegen et al. 2015d	0.09	0.68	0.77	0.43	1.20	756%	56%
Tegen et al. 2015a	0.08	0.88	0.96	0.67	1.63	1100%	70%
Sondes & Jean Christophe 2018b	0.08	0.90	0.98	0.68	1.66	1125%	69%
Zammit & Miles 2013	0.08	0.90	0.98	0.69	1.67	1125%	70%
Tegen et al. 2015c	0.07	0.79	0.86	0.44	1.30	1129%	51%
wind jobs.xlsx							

The table shows identified studies that contained estimates for direct, indirect and induced jobs in the operational phases of an offshore wind project. Some other studies such as IRENA 2018 contained estimates for direct and indirect jobs, but not induced jobs.

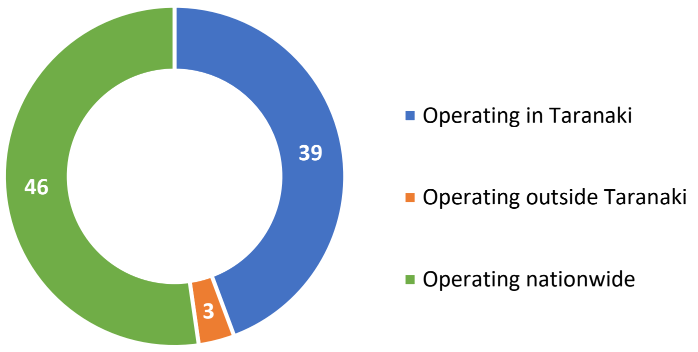
Appendix C: Survey summary

Concept used an online survey tool to collect information from potential suppliers to an offshore wind industry. Responses were received from 88 individual parties (responses were received from different individuals within some single organisations – these were reconciled to avoid apparent duplication when analysing data). Organisations varied from very small (1-2 people) through to those with many hundreds of employees.

The charts below record the number of respondents expressing interest in providing various services. The differences in scale across respondents should be borne in mind when interpreting the charts.

As shown by Figure 18, most of the survey respondents had operational footprints in Taranaki or operated nationwide.

Figure 18: Operational footprint of survey respondents

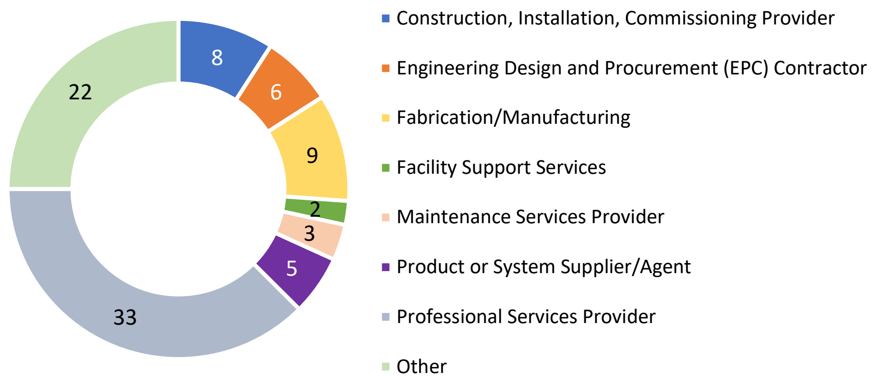


survey and database.xlsx

Source: Concept analysis of survey responses.

The largest grouping of respondents were professional services organisations, followed by providers of facilities support services. A breakdown of all categories of service provider types is shown in Figure 19.

Figure 19: Organisational type of survey respondents



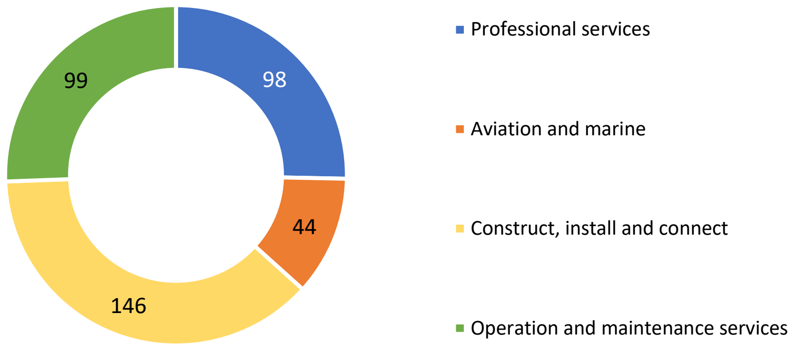
survey and database.xlsx

Source: Concept analysis of survey responses.

Survey respondents were invited to indicate their level of provider interest across 41 different service sub-types.[35] These sub-types were grouped into the five service categories, and the level of interest in each category is shown in Figure 20.

This chart shows a significant level of interest across all categories, but especially professional services, construction related services, and operations and maintenance services.

Figure 20: Respondents interested in providing service sub-types



survey and database.xlsx

Source: Concept analysis of survey responses. Note some providers expressed interest in providing multiple service sub-types, e.g. marine and port services. Hence the number of positive responses exceeds the number of individual respondents.

Where respondents indicated an interest in providing a service sub-type, they were asked to rate their readiness based on the following criteria:

- Limited readiness - some experience in other sectors but significant preparation (e.g. plant investment) required to serve offshore wind industry.
- Moderate readiness - extensive relevant experience and only limited preparation (e.g. cross-training) required to serve offshore wind industry.
- Full readiness - currently providing this category of product/service to other sectors.

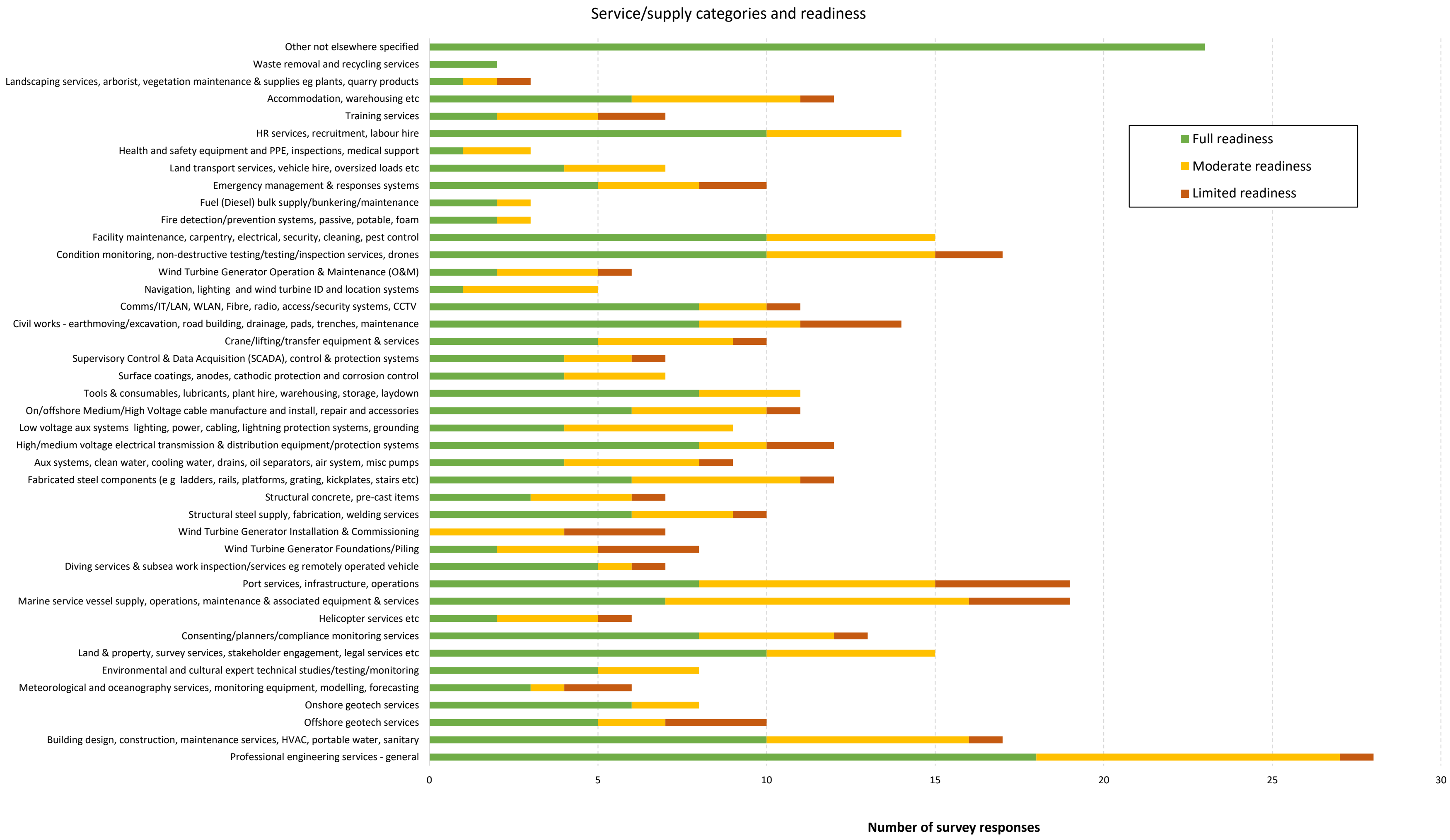
Figure 21 shows the number of respondents in each readiness rating for each of the service sub-types.

Key observations include:

- Many respondents assessed themselves as fully ready (shown as green bars)
- A substantial number of respondents assessed themselves as having moderate readiness (shown as amber bars)
- Relatively few responses were recorded from parties indicating they had limited readiness.

[35] For example, the aviation and marine service category includes helicopter, marine logistics, diving and subsea inspection, and port services.

Figure 21: Service/supply categories and level of readiness



Source: Concept analysis of survey responses.