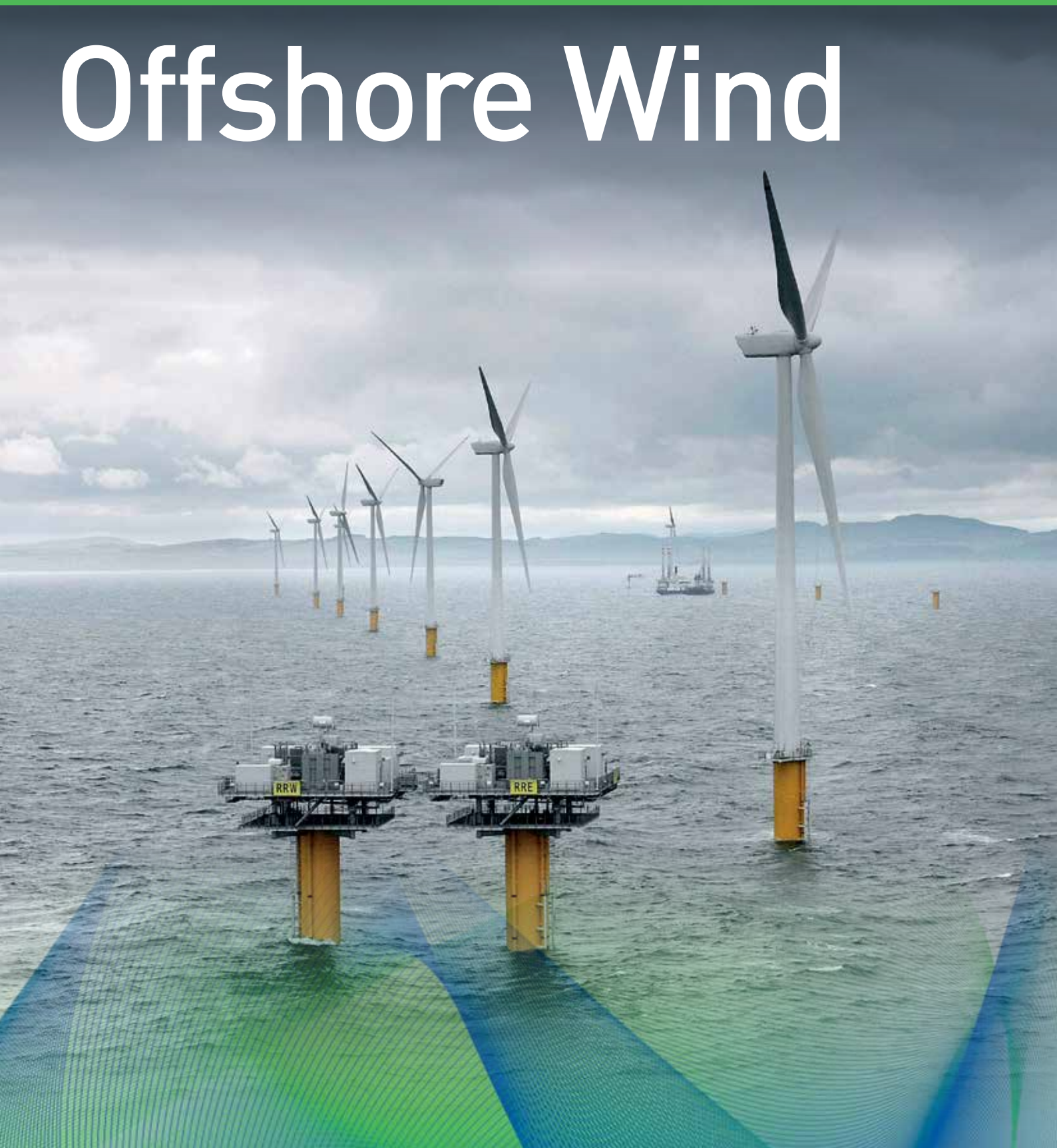
Scottish Enterprise

Oil and Gas 'Seize the Opportunity' Guides

Offshore Wind



Contents

This publication has been produced for Scottish Enterprise by BVG Associates. BVG Associates is a consultancy with expertise in wind and marine energy sectors committed to developing the UK supply chain. BVG Associates helps a wide range of clients around the globe with technical, economic and business advice. Their team has vast experience across engineering, supply chain, commercial and RD&D departments of major manufacturers. BVG Associates clients include market leaders and new entrants in the wind and marine energy sectors across the globe, as well as enabling bodies such as Scottish Enterprise.

Executive summary

Offshore wind presents a considerable diversification opportunity for Scottish oil & gas companies, provided they act ahead of the global deployment boom. The world's offshore wind capacity has more than trebled in the past five years, growing from 3.1 gigawatts (GW) in 2011 to 11.7GW in 2015. Within the next five years, global capacity is forecast to reach 40GW, and within ten years, it could reach in excess of 60GW, representing capital and operational expenditure in the region of £210bn over the ten year period.

Europe is currently at the forefront of offshore wind development, accounting for over 92% of global offshore wind deployment to date. The region is forecast to build approximately 25GW of offshore wind by the end of the decade, worth an estimated £60 billion in capital and operational expenditure over the next five years. To place this in context, the cumulative cost of decommissioning North Sea oil & gas assets is estimated to be £46 billion by 2040.

Cost reduction will be critical to achieving these forecasts and maintaining offshore wind's growth in the longer-term, as although offshore wind is a proven technology, it remains reliant on policy support. Feed-in tarrifs and feed-in premiums are the primary forms of financial support within Europe, providing offshore wind generators with the certainty of income needed to commit to the multi-billion pound investment costs of new projects. Through these and other support measures, governments are seeking to build an industry of scale, encourage competiton, and ultimately bring down the cost of offshore wind energy.

There is broad acceptance of the necessity of cost reduction across the offshore wind industry. Developers and Tier One suppliers are actively looking for solutions to bring down costs, including incorporating best practice from other sectors. The industry is therefore open to new entrants from the oil & gas sector that can deliver this type of cross-sector expertise.

This guide identifies nine areas that present the greatest opportunities for oil & gas companies to diversify into offshore wind:

1. Project management
2. Array cables
3. Substation structures
4. Turbine foundations
5. Secondary steelwork
6. Cable installation
7. Installation equipment
8. Installation support services, and
9. Maintenance and inspection services.

As summarised in Figure 1, each of these nine areas exhibit a high level of synergy with the oil and gas sector and can benefit from the expertise and capabilities of the oil & gas supply chain. However, oil & gas companies must also recognise the differences between the sectors, and acknowledge the different practices that have been adopted by offshore wind for good reasons in many cases.

There are already many firms from an oil and gas background that are successfully operating within offshore wind. This guide profiles nine such companies — TNEI, Tekmar, Sembmarine SLP, Global Energy Group, Hutchison Engineering, DeepOcean, W3G Marine, FoundOcean and 3sun — each of whom describe the challenges they faced to market entry, and explain the solutions they were able to bring to bear in order to win business in the offshore wind sector. Scottish Enterprise and BVG Associates would like to extend our grateful acknowledgement to these nine companies for agreeing to share their experiences within this guide.

Offshore wind is a growing market that presents exciting new business opportunities for oil and gas supply chain companies. This guide, along with the sources of information and support that are profiled within it, is intended to help companies realise these opportunities.

This guide has been designed to help oil & gas supply chain companies consider opportunities to diversify into offshore wind. Companies can use this guide to:

- Understand the size of the offshore wind market and its main drivers
- Understand the similarities and differences in ways of working between offshore wind and oil & gas.
- Understand where they fit within the offshore wind supply chain
- Understand the cost dynamics of the offshore wind sector and the technology trends across the next decade, and
- Understand the major offshore wind procurement processes and trends, and
- Support the development of market entry and market growth strategies.

Key concepts and opportunities for companies seeking to diversity into offshore wind are explored within the following sections of the guide:

Offshore wind expenditure
The guide opens with an examination of the cost profile and cost breakdown of a representative 500MW offshore wind farm project.

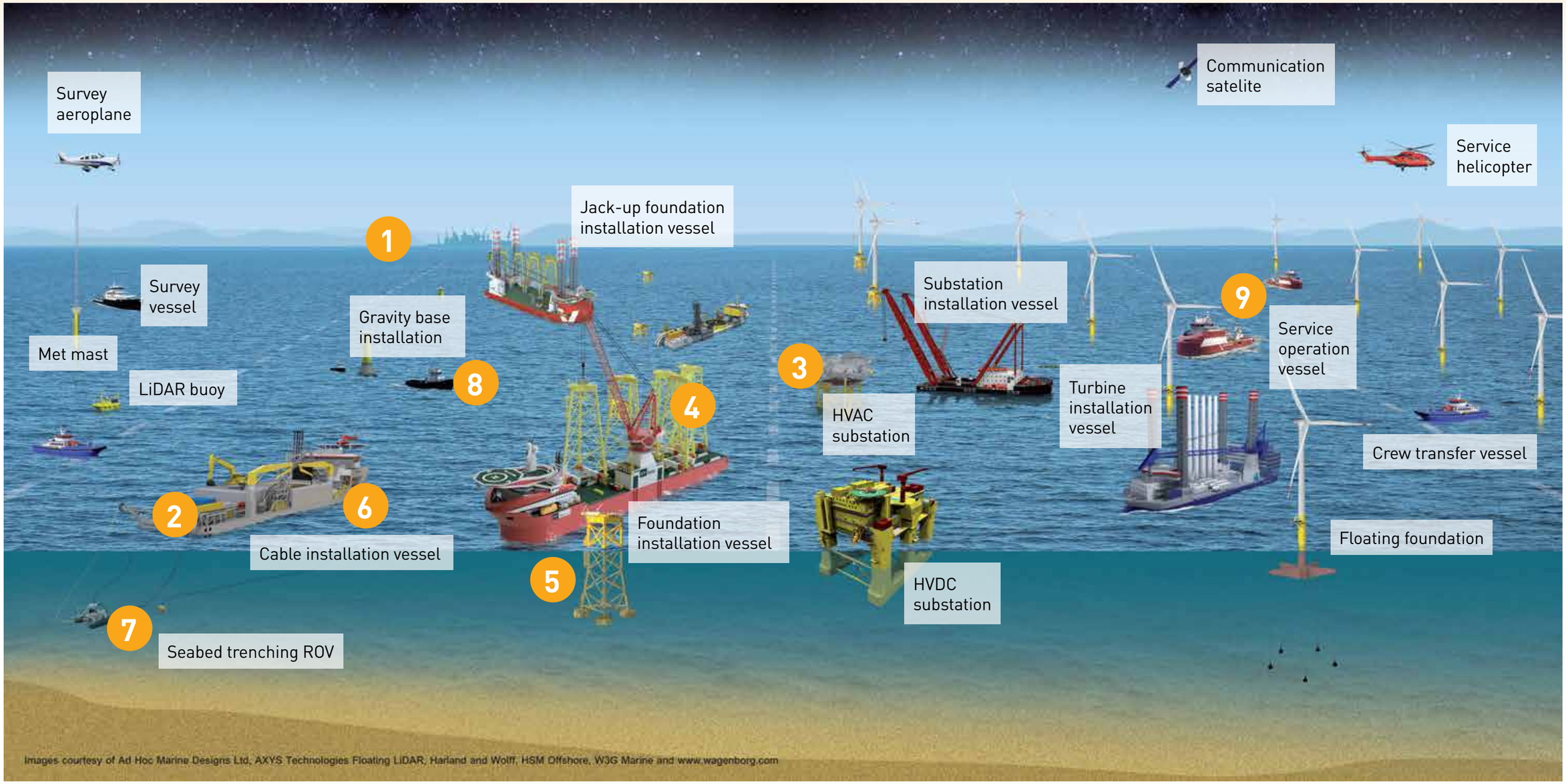
Opportunity mapping
The opportunity mapping section looks at 35 sub-elements of the offshore wind supply chain to identify those which are most accessible for oil & gas companies.

High potential opportunities
The high potential opportunities section of the guide profiles the nine areas of the offshore wind supply chain that present the greatest opportunities for oil & gas companies. It also features case studies of companies that have successfully made the transition from oil & gas into offshore wind.

Market growth
The market growth section explores global offshore wind markets, focusing on key regions and countries. It examines the dynamics of each market and forecasts capacity deployment to 2025.

Strategies for market entry
The strategies for market entry section examines the differences between oil & gas and offshore wind sectors, identifies the capabilities of most relevance to the offshore wind supply chain, and looks at how oil & gas companies can address barriers to market entry.

Support for Scottish companies
The guide concludes with an overview of the support available to help Scottish oil & gas companies diversify into offshore wind.



1. Project management	Oil and gas companies are already offering skills in managing complex projects offshore
2. Array cables	Their manufacture requires similar skills and equipment to oil and gas umbilical manufacture
3. Substations structures	These are typically one-off designs on a similar scale to oil and gas platforms
4. Turbine foundations	Fabrication skills from oil and gas can be harnessed to produce serially manufactured structures
5. Secondary steelwork	This is an accessible market for companies without the capacity for foundation manufacture and entry may not need new coastal facilities
6. Cable installation	Most experienced contractors have not only oil and gas experience but learned that the complexity of offshore wind contracts presents significant new challenges
7. Installation equipment	The transition from oil and gas equipment supply has been made by a significant number of companies, for example in pile and cable handling equipment and trenching and burial tools
8. Installation support services	The experience of working offshore can bring real benefits to offshore wind not only in subsea services such as diving and ROV services but also in onshore activities such as marine consultancy
9. Maintenance and inspection services	Oil and gas experience of offshore logistics can shape evolving strategies in offshore wind

Figure 1 – Summary of oil and gas industry opportunities in offshore wind

Offshore wind expenditure

The lifetime undiscounted cost of a 500MW wind farm reaching final investment decision (FID) in 2020, using 8MW turbines, on jacket foundations, in 45m water depth, 40km from shore is about £5.4 billion. This report considers six main supply chain elements.

Development and project management: the development and project management of the offshore wind farm from the point of signing a lease exclusivity agreement to the construction works completion date.

Turbine: the manufacture, assembly and system-level functional test of all electrical and mechanical components/systems that make up a wind turbine, including the nacelle (generator and housing), rotor and tower.

Balance of plant: all aspects of the supply of cables, turbine foundations, and offshore and onshore substations.

Installation and commissioning: the commissioning work on all balance of plant and turbine sub-elements.

Operation, maintenance and service: all operational, inspection and service costs for the lifetime of the asset. Costs are split into two main areas:

- Minor service and day-to-day operations: cost of day-to-day control of the wind farm including planned maintenance, condition monitoring and equipment and labour rental costs.
- Major service: cost of major component repair or replacement, including vessel rental.

Decommissioning: includes all works associated with the removal of end of life assets, salvage and recycling, but excludes the scrap value.

An offshore wind farm lifecycle can exceed 30 years from initial concept planning through to decommissioning. Development spend happens many years before a wind farm reaches FID. Development spend is considered a risk cost because there is no guarantee that a project will move to construction at this early stage. Other capital expenditure (CAPEX), including turbine, balance of plant and installation, is usually only committed at FID.

Operational expenditure (OPEX) makes up a significant portion of lifetime expenditure but it is spread across the operational life of the wind farm, which for new wind farms is about 25 years. The profile of the lifetime spend is illustrated in Figure 2 with total spend by area on a standard offshore wind farm shown in Figure 3. A cross-reference of oil and gas spend areas mapped to offshore wind spend areas can be found in Appendix E.

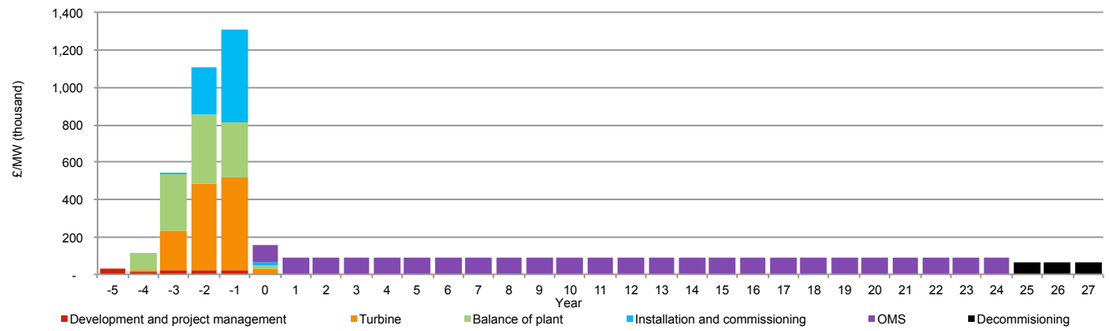


Figure 2 – Breakdown of spend during wind farm lifecycle

CAPEX (up to 3 years)				OPEX (up to 25 years)	DECEX (up to 3 years)
Development: Project developers, Survey companies, Consenting service companies, Project management companies	Turbine supply: Project developers, Wind turbine manufacturers, Component manufacturers, Assembly contractors	Balance of plant: Project developers, Balance of plant component manufacturers	Installation: Project developers, Installers, Electrical contractors, Ports	Operations: Asset owner, Wind turbine manufacturers, Project management companies, Third party O&M providers, Ports	Decommissioning: Asset owner, Survey companies, Project management companies, Marine operation companies
£160m / 3% of lifetime spend	£1.382b / 25% of lifetime spend	£957m / 17% of lifetime spend	£590m / 11% of lifetime spend	£2.275b / 40% of lifetime spend	£207m / 4% of lifetime spend

Figure 3 – Breakdown of spend by area

Opportunity mapping

In order to identify specific opportunities for oil & gas companies, the six main elements of the offshore wind supply chain have been broken down into a further 35 sub-elements. For example, the Turbine Supply element has been divided into seven sub-elements comprising Turbine Assembly, Blades, Drive train, Power Conversion, Large Fabrications, Towers and Small Components. Each of the 35 supply chain sub-elements have been screened against six criteria that assess the ease of market entry for oil & gas companies:

1. Oil and gas track record in offshore wind
2. Oil and gas sector synergies
3. Appetite from offshore wind
4. Potential for levelised cost of energy (LCOE) benefit from new involvement by oil and gas companies
5. Size and timing of investments by oil and gas companies
6. Size of the opportunity

The scoring matrix (opposite) explains the scoring criteria applied to each supply chain sub-element and Table 1 (below) shows the results of the screening exercise.

Green-light opportunities have been identified as those areas of the offshore wind supply chain that present oil and gas suppliers with the greatest opportunity to support.

Areas of supply denoted as **amber** or **red** are still an opportunity for supply, the assessment simply considers where the logical argument exists for the best chance of diversification success.

A percentage cost of each element is shown in Figure 4.

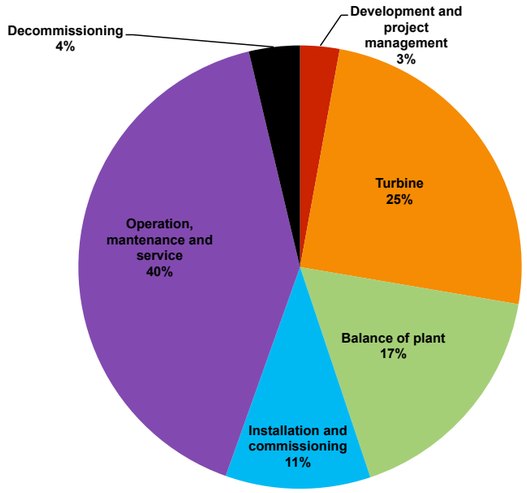


Figure 4 – Cost breakdown of an offshore wind farm reaching final investment decision in 2020

Score				
Criterion	**1**	**2**	**3**	**4**
Oil and gas track record in offshore wind	No known O&G companies with a track record in offshore wind in the last three years	← 25% of the companies that have supplied offshore wind in the last three years have an O&G background	← 75% of the companies that have supplied offshore wind in the last three years have an O&G background	Almost all of the companies that have supplied offshore wind in the last three years have an O&G background
Oil and gas sector synergies	Limited synergies between offshore wind and O&G	Some synergies between offshore wind and O&G but significant learning needed by new entrants	Many synergies between offshore wind and O&G and some learning would be needed by new entrants	Strong synergies between offshore wind and O&G and goods and services can be supplied to offshore wind without much learning
Appetite from offshore wind (For wind farms reaching FID in 2015)	Strong competition between five or more mature players using optimal technical solutions	Healthy competition between three to four players using technical solutions close to optimal	Competition between three to four players but technical solutions for some tasks are suboptimal. There is demand for new solutions from parallel sectors	Less than three established suppliers and/or the technical solutions for critical tasks are suboptimal. There is demand for new solutions from parallel sectors
Potential for LCOE benefit from new involvement by oil and gas companies (For wind farms reaching FID in 2020)	Standard technology in offshore wind is close to optimal with few opportunities for O&G companies.	Standard technology in offshore wind is well established with O&G companies only likely to contribute about 0.1-0.5% of LCOE reduction to wind farms	Standard technology in offshore wind is adequate but oil and gas companies could contribute between 0.6% and 1% of LCOE reduction to wind farms	Standard technology in offshore wind is immature or inadequate and oil and gas companies could contribute more than 1% of LCOE reduction to wind farms
Size and timing of investments by oil and gas companies (For wind farms reaching FID in 2017)	Significant investments are needed to be competitive for projects that need to be amortised over several orders. Investment must be made before a confirmed order	Significant investments are needed to be competitive for projects that need to be amortised over several orders. Investment can be made before the first confirmed order	Significant investments are needed to be competitive for projects but they can be set against a single project. Investment can be made in response to a confirmed order	Minor investments can be made incrementally to be competitive. Investment in response to a confirmed order
Size of the opportunity	The serviceable market opportunity is less than 1% of lifetime expenditure	The serviceable market opportunity is between 1% and 2% of lifetime expenditure	The serviceable market opportunity is between 2% and 5% of lifetime expenditure	The serviceable market opportunity is greater than 5% of lifetime expenditure

Scoring Matrix

Element	Sub-element	Oil and gas track record in offshore wind	Oil and gas sector synergies	Appetite from offshore wind	Potential for LCOE benefit from new involvement by oil and gas companies	Size and timing of investments by oil and gas companies	Size of the opportunity	Opportunity for oil and gas companies
Development and project management	Environmental surveys	2	2	1	1	4	1	
	Consenting and development services	1	4	1	1	4	1	
	Site investigations	4	3	2	1	4	1	
	Project management	3	4	2	2	4	1	
Turbine supply	Turbine assembly	1	1	1	1	1	1	
	Blades	1	1	1	1	1	1	
	Drive train	1	1	1	1	1	1	
	Power conversion	1	1	1	1	2	1	
	Large fabrications	1	2	1	1	2	3	
	Towers	1	2	2	1	2	3	
	Small components	1	2	1	1	2	3	
Balance of plant	Array cables	4	4	2	2	2	3	
	Export cables	2	2	2	2	1	2	
	Transmission	1	1	1	1	1	1	
	Substation structures	4	4	3	4	3	4	
	Turbine foundations	3	3	4	4	1	4	
	Secondary steelwork	3	3	2	2	4	2	
Installation and commissioning	Installation ports and logistics	1	4	1	1	3	1	
	Turbine and foundation installation	2	3	2	2	3	3	
	Cable installation	3	4	4	2	4	2	
	Substation installation	2	2	3	1	4	2	
	Installation equipment	4	4	4	4	4	2	
	Installation support services	4	4	4	4	4	2	
	Onshore works	1	1	1	1	4	1	
Operation, maintenance and service	Fuel and consumables	1	3	1	1	4	1	
	Maintenance and inspection services	2	4	3	3	4	4	
	Offshore logistics	1	3	3	3	4	1	
	Vessels and equipment	1	3	3	3	3	2	
	Operations port	1	3	2	1	4	1	
	Communication systems	2	4	3	1	4	1	
	Inventory management	1	3	4	3	3	1	
Decommissioning	Ports and logistics	1	4	2	1	4	1	
	Marine operations	1	4	3	1	4	1	
	Salvage and recycling	1	4	4	1	4	1	
	Project management	1	4	3	1	4	1	

Table 1 – Sub-element opportunity scores

High potential opportunities

The screening process has identified nine high potential areas of opportunity:

- Project management
- Array cables
- Substation structures
- Turbine foundations
- Secondary steelwork
- Cable installation
- Installation equipment
- Installation support services, and
- Maintenance and inspection services.

Each of these offshore wind sub-elements are examined within this section to consider nature and scale of the opportunities for oil and gas supply chain companies. Case studies on oil and gas companies that have sucessfully diversified into these sub-elements are also provided within this section.

Development and project management

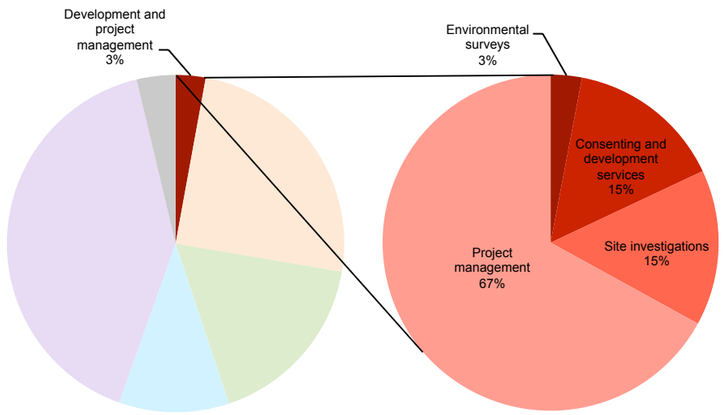


Figure 5 – Breakdown of costs in the development and project management sub-element

Development and project management makes up 3% of lifetime expenditure (Figure 5) of an offshore wind farm. Although this represents a comparitively small cost element over the 30+ year life cycle of a wind farm, expenditure on project management sub-element alone is still in the order of £105 million for a representative 500MW project. Opportunties exist for oil & gas companies in this sub-element.

During site selection, contractors carry out geotechnical and geophysical studies to identify suitable locations for deployment, including cable routes. Developers carry out on-grid connection assessments and submit a number of applications and consents. Much of this has already been undertaken for UK projects with oil and gas companies playing a significant role.

No two offshore wind farms are the same and a number of specialist tasks are needed across all stages of the development process. Developers may subcontract the project management and coordination of specialist tasks throughout the process.

Securing this specialist advice represents a significant expense for any project developer. In general, the following support services would normally be required: surveys, legal, planning, consent applications, financial due diligence, stakeholder engagement, geotechnical and socio-economic assessments.

Table 2 shows an assessment of the opportunities for oil and gas companies within development and project management, with project management representing the most significant sub-element opportunity.

Sub-element	Lifetime spend for a 500MW wind farm		Oil and gas opportunity
Environmental surveys	0.1%	£5 million	
Consenting and development services	0.4%	£24 million	
Site investigations	0.4%	£24 million	
Project management	1.9%	£105 million	

Table 2 – Development and project management opportunities

Project management

Details of opportunities within project management are shown in Table 3.

Criteria	Score	Comments
Oil and gas track record in offshore wind	3	A number of companies with a background in oil and gas have carried out work in offshore wind, including DNV-GL, ODE, and TNEI.
Oil and gas sector synergies	4	Project management in the marine environment is similar in offshore wind and oil and gas. The challenges of working in a harsh environment and the ensuing implications for HSE, for example, mean that oil and gas companies are well placed for work in offshore wind.
Appetite from offshore wind	2	Developers are aware that companies from oil and gas have world class project management capabilities. The market is well served in this area, but opportunities do exist for new entrants who understand the challenges associated with operating in harsh environments.
Potential for LCOE benefit from new involvement by oil and gas companies	2	Although developers are always looking for opportunities to run projects quicker and more effectively, this is not an area where large cost reduction is expected. Strong project management reduces project risk and will be a factor in cost of capital calculations.
Size and timing of investments by oil and gas companies	4	Little investment will be required by oil and gas companies to diversify.
Size of the opportunity	1	There is relatively low spend across a number of years so oil and gas companies need to seek multiple projects to make participation in offshore wind viable.

Table 3 – Diversification opportunities within project management

CASE STUDY – TNEI

Sub-element: Project management

Background: Established in 1995, TNEI is a specialist energy and environmental consultancy and software provider. Its consultants deliver expert advice in the key service areas of power system analysis and design, planning, consenting and environmental surveys & assessments. TNEI has UK offices in Glasgow, Manchester and Newcastle.

Challenge: Developers contract out a wide array of expert consultancy and project management services during the planning and development phase of an offshore wind project. Developers want suppliers that can support several areas rather than use many single area specialists. "The offshore wind projects which we are involved in provide us with continual contact with the technology supply chain and the latest industry regulations and guidance, which keeps us up to date with current and future developments. Keeping abreast of changes within an industry going through rapid evolution has been a key element of our growth success," says Rachel Hodges, Managing Director of TNEI.

Solution: TNEI started to increase its focus on the offshore wind sector in 2007. The company was acquired by oil and gas giant Petrofac in 2010 to develop its new energy capability, focusing on offshore wind. Petrofac identified the benefit of widening its offering into expert project management; via TNEI, it developed proprietary software which enabled the analysis of large numbers of array layouts. According to Rachel, "Petrofac saw the acquisition of TNEI as a key step towards developing a presence in the renewable market. There was a realisation of the benefits that offshore oil and gas expertise could bring to the emerging offshore wind sector".

Results: TNEI has expanded rapidly, establishing a reputation for innovation, expertise, industry knowledge and quality of service. The company has developed a strong market position within the project management sub-element of offshore wind in three main areas:

- Engineering and principal designer services, including site feasibility assessments, substation and foundation design, geotechnical due diligence and asset inspection. TNEI is often called upon to act as the developer or financier's engineering capability. "Our service is tailored to the client's specific needs. By providing early input at the development stage, we can ensure that wind farm designs are cost effective and buildable, minimising potential delays and cost over-runs later" says Rachel.
- Power systems and technology, covering all aspects of the electrical system design from technical due diligence on next generation technology, specific technical studies, through to full system concept design and FEED. Since joining Petrofac in 2010, TNEI has offered wider services, including full substation platform and foundation engineering, operations and maintenance mapping and offshore cable routing. TNEI has provided significant input to the Moray offshore wind farm in Scotland.
- Planning and environmental, including technical and environmental consultancy, specialising in noise modelling, ecological surveying, site constraint and layout design as well as specific assessments such as shadow flicker.

"If you are a supplier or consultancy looking to break into offshore wind, it is paramount that you market yourself and attend as many industry events as possible. We produce a number of industry papers and join professional industry enabling organisations wherever possible – we have found this to be extremely effective for growing our presence within the sector", says Rachel.

Turbine

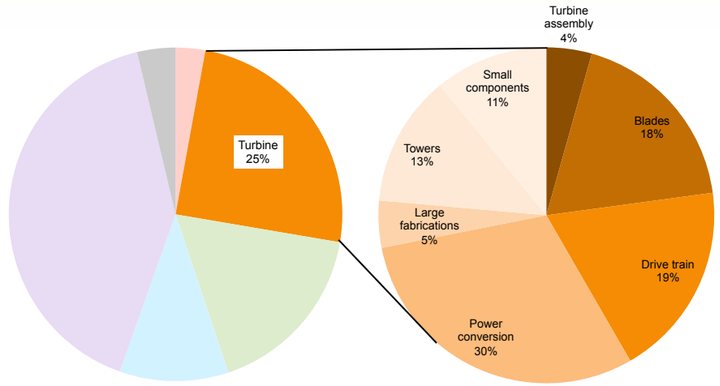


Figure 6 – Breakdown of costs in the turbine supply sub-element

Turbine supply involves the design, manufacture and assembly of all electrical and mechanical components and systems that make up a wind turbine. It is the single biggest contract placed by the developer, but does not represent a major opportunity for oil and gas companies.

The wind turbine manufacturer is a systems integrator and assembles the final product using components that are manufactured in-house or externally sourced.

The nacelle components include the bedplate, drive train, power take-off, control system, yaw system, yaw bearing, auxiliary systems, cover, fasteners and conditioning monitoring system.

The rotor components include the blades, hub casting, blade bearings, pitch system, spinner, auxiliary systems, fabricated steel components and fasteners.

The tower components include steel plate, personnel access and survival equipment, electrical system, tower internal lighting and fasteners.

Many suppliers serve both the onshore and offshore wind markets, and recent reductions in onshore wind deployment has led to some excess capacity.

Strong local supply chains have grown in overseas markets where offshore wind first emerged. Significant infrastructure investment has been made on the Continent, particularly in portside manufacturing capability and load out facilities. Oil and gas suppliers are therefore competing with a supply chain that has 20 years of offshore wind track-record.

Turbine manufacturers are reluctant to risk switching suppliers unless significant cost or quality benefits can be realised. New supplier identification and qualification is an unwanted cost to turbine manufacturers at a time when cost reduction is required across the sector.

High volume, low IP components such as towers, already have well-established manufacturers experienced in working in this low margin area of supply.

Opportunities for the Scottish supply chain to support turbine supply are most probably limited to sub-contract partnerships with existing suppliers.

Sub-element	Lifetime spend for 500MW wind farm		Oil and gas opportunity
Turbine assembly	1.1%	£60 million	
Blades	4.6%	£255 million	
Drive train	4.7%	£260 million	
Power conversion	7.5%	£420 million	
Large fabrications	1.1%	£65 million	
Towers	3.1%	£175 million	
Small components	2.7%	£150 million	

Table 4 – Turbine supply opportunities

Balance of plant

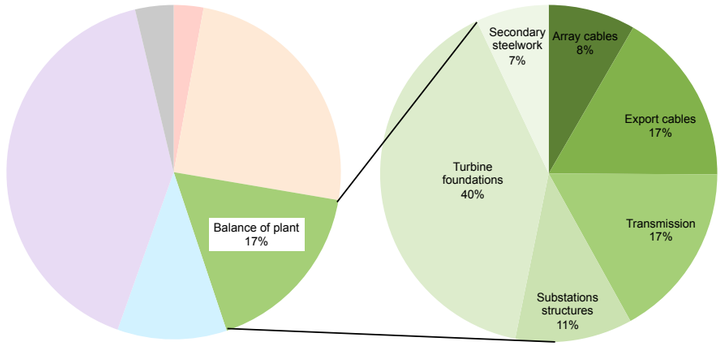


Figure 7 – Breakdown of costs in the balance of plant sub-element

Balance of plant unit costs will increase over time as wind farms go further offshore and into deeper water. Overall, however, total costs will go down as turbine capacity increases meaning fewer units are required.

Balance of plant is expected to deliver significant LCOE improvement; innovative oil and gas companies are already finding opportunities in several sub-elements.

Sub-element	Lifetime spend for 500MW wind farm		Oil and gas opportunity
Array cables	1.4%	£80 million	
Export cables	2.9%	£160 million	
Transmission electrical	2.9%	£160 million	
Substation structures	1.9%	£105 million	
Turbine foundations	6.8%	£380 million	
Secondary steelwork	1.2%	£70 million	

Table 5 – Summary of balance of plant opportunities

Oil and gas suppliers have a strong track-record in this area of offshore wind and the synergies between the sectors are high. In particular, array cables, substation structures, turbine foundations and secondary steelwork all show good opportunities for oil and gas suppliers and are examined in more detail in this section.

By way of contrast, export cable supply opportunities are limited as the offshore wind market is well served by large cable manufacturing companies operating across multiple industries. Companies like Prysmian and Nexans operate in both sectors, but new entrants from oil and gas would likely need to invest in capability and infrastructure with no guaranteed offshore wind pipeline.

Transmission electrical supply is mainly supported by global engineering companies such as ABB, GE and Siemens.

Array cables

Array cables connect the individual turbines to one another and to the substation, if present. Array cable and ancillary equipment demand within offshore wind is well supported by companies with an oil and gas background.

Synergies between both sectors are extremely high and diversification opportunities are therefore good. Incumbent offshore wind suppliers have strong capabilities and framework agreements are in place with some developers.

Criterion	Score	Comments
Oil and gas track record in offshore wind	4	JDR Cables has successfully entered the offshore wind sector from the oil and gas sector and has become the number one array cable supplier in Europe. Oil and gas suppliers of ancillary equipment such as cable joints and terminations, cable protection systems and buoyancy modules are winning business in offshore wind.
Oil and gas sector synergies	4	Offshore wind array cable requirements are slightly different than in the oil and gas sector where there is a specific need for medium voltage cable testing, large storage capacity and roved jackets. However, most oil and gas suppliers are capable of supplying offshore wind projects without significant investment. Lower tier cable components such as connectors, terminations, hang-offs and cable protection have strong synergies with the oil and gas sector.
Appetite from offshore wind	2	The MV array cable market is already well served by a number of large cable manufacturers. There has been significant market consolidation with Prysmian buying Draka and Parker Scanrope withdrawing from the market. Large cable manufacturers may target the more lucrative export cable market; JDR is the only manufacturer to focus only on MV cable supply. Offshore wind developers want to increase local content and harness the innovation from oil and gas. Much of this demand will be for lower tier cable components such as connectors, terminations, hang-offs and cable protection.
Potential for LCOE benefit from new involvement by oil and gas companies	2	The Carbon Trust has made £300 million of funding available to support the commercialisation of next generation DC array cables, innovative aluminium designs and the development of 66kV cable designs, which have the potential to lead to a lower LCOE than the current 33kV designs. Oil and gas cable expertise has the potential to reduce LCOE in areas such as cable design, reliability and, for floating wind farms in particular, dynamic cables and flotation aids.
Size and timing of investments by oil and gas companies	2	Developers view array cables as a commodity item and use competitive tenders for project specific work packages. DONG uses a framework approach to standardise the cable-foundation interface for projects. Oil and gas companies may be reluctant to invest without the security of such a framework agreement.
Size of the opportunity	3	The majority of the value in this sub-element comes from the manufacture of the cable cores. The UK has no capacity to manufacture cable cores for subsea cables so the overall attainable value of these work packages is limited. Successfully diversifying into offshore wind is likely to be linked to an aspiration to win a number of contracts across multiple projects where margins can be protected via design economies of scale and standardisation.

Table 6 – Diversification opportunities within array cables

CASE STUDY – TEKMAR

Sub-element: Array cables

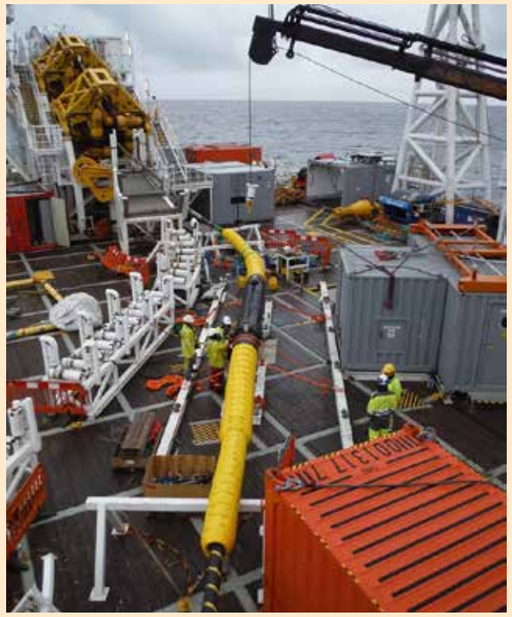
Background: Founded in 1985 as an oil and gas diving consultancy, Tekmar opened its first manufacturing facility in 1995 to provide lifting and mechanical solutions to the oil and gas sector. With headquarters in Newton Aycliffe, England, the company has grown and now has a sales presence in USA, Germany and UAE. Today, Tekmar is a market-leading provider of subsea cable, umbilical and flexible pipe protection systems and engineering services to the offshore marine sector.

Challenge: New entrants to the offshore wind sector face the twin challenges of displacing the existing supply chain and of introducing innovative new concepts to a risk-averse industry seeking rapid cost reduction.

Solution: Having developed a number of key competencies in the oil and gas sector, Tekmar Energy was launched to serve the offshore wind sector, providing design, engineering and manufacturing capability of subsea cable protection systems. "We took the strategic decision to enter the renewable sector first and foremost because we saw an exciting and growing market on our doorstep. The challenge of installing cables is very similar for both sectors but we realised quickly that offshore wind needed bespoke solutions and this married perfectly with the innovative ethos we have here at Tekmar," says James Ritchie, CEO of Tekmar.

In response to the demand from the renewables sector, Tekmar developed a new innovative solution called TekLink. Tekmar continued to innovate and in 2014 launched its TekTube solution specifically designed for O&G brownfield work as well as future offshore wind projects to help drive down costs, improve installation rates and to ensure cable integrity for the service life (typically 25 years).

"Innovative, technological improvements such as our cable protection systems can help towards creating a step-change in electrical cable technology which will help to minimise costs within the industry. The fact we are able to develop solutions which can be deployed in both sectors allows us to share best practice across industries," says James.



CASE STUDY – TEKMAR

Results: Offshore wind developers are keen to work with supply partners who can contribute proactively during the design phase and can offer more than just manufacturing capability. A major part of Tekmar's success in offshore wind is the breadth of expertise covering early concept R&D, design engineering, in-house product testing capability, project management, expert personnel training and general offshore support.

Tekmar is well placed to comment on the differences between both sectors: "While our core markets in offshore wind and oil and gas share similar offshore environments, Tekmar recognises there is an inherent difference in the drivers behind them. The challenge for the developing offshore renewable industry is to make alternative energy sources competitive against conventional means. This drives the need for new technologies and innovation. In contrast, the mature offshore oil and gas industry prioritises proven technology in quality, reliability and track record," says James.

Substation structures

All new offshore wind projects with a capacity larger than 100MW need a substation. Projects approaching 500MW of generating capacity are likely to require two substations. Developers may award an engineering, procurement, construction and installation (EPCI) contract to an electrical supplier such as Siemens or GE for the substation, although they may contract the foundation separately. DONG engineers its own substations and awards multiple contracts for components.

Substations are made up of a number of sub-elements including the platform, secondary steel, architectural items and the foundation. Modular substations with equipment housed on a turbine foundation are likely to enter the market soon. Similar to oil and gas offshore structures, some developers may move towards a solution where adjoining combination platforms next to substations become the norm. While fixed structures of this nature offer some advantages, a number of developers see service operation vessels (SOV) as a better option for accommodating personnel as they can transfer workers directly to the turbines in poor weather.

High voltage AC substations are used in near-shore projects but are not generally suitable beyond 50 miles of transmission. Far-shore sites will need innovative AC solutions or will require the introduction of high voltage DC transmission systems.

Innovative AC solutions include the introduction of a reactor station along the export cable route and the development of low frequency transmission solutions.

HVDC substations use more expensive high power semiconductor converters. They are also much bigger than HVAC stations thus increasing the installation cost and restricting the number of yards that can build them. Several projects in Germany have used DC substations but none have been deployed in the UK so far.

There are only limited cost benefits from substation structure construction close to the wind farm site.

Criteria	Score	Comments
Oil and gas track record in offshore wind	4	The offshore oil and gas sector has sustained a supply base for offshore platform construction for many years. Several large international companies with a presence in oil and gas have a successful track-record supplying offshore wind with foundations, topside structures and architectural components. Companies with a strong presence include Bladt, Heerema, HSM Offshore and Sembmarine SLP. In winning the substation topside contract for the Rampion offshore wind farm, and the contract to supply the world's first reactive compensation substation for Hornsea One, Babcock has joined the offshore wind supply chain and it is targeting further business within the sector.
Oil and gas sector synergies	4	There is significant synergy between offshore wind substations and oil and gas platforms and accommodation modules. The further integration of accommodation and maintenance facilities on offshore wind substations will increase this synergy further. Although the offshore wind market is maturing and DONG has developed a standardised design across three wind farms, there are no industry-wide standards for substation design. This is a good fit with the oil and gas construction model, which is usually focussed on bespoke solutions. Substation contracts are often awarded on a multi-contract or EPCI basis with developers seeking supply chain partners with strong energy transmission or offshore marine engineering credentials. Oil and gas suppliers understand the prevalent contracting models for these types of structures and a strong track-record in a more mature sector can be a major advantage.
Appetite from offshore wind	3	There are a large number of yards around Europe that can meet the demand for AC substations and no shortfall in capacity is anticipated in the short term. Capacity for building DC platforms is more limited and fewer UK yards have the necessary infrastructure required. The biggest industry risk is a potential supply bottleneck from simultaneous demands on larger construction yards. The appetite for new market entrants is reasonably strong in the longer term; developers are keen to stimulate competition and it is likely work packages will be split into sub-packages.
Potential for LCOE benefit from new involvement by oil and gas companies	4	Due to the high proportion of project lifetime spend, industry expects savings to be delivered in substation supply via innovative engineering designs and techniques. Developers believe that by simplifying and standardising topside designs, costs may be reduced significantly. Oil and gas fabricators are well placed to develop core products that can be adapted to meet the needs of individual projects.
Size and timing of investments by oil and gas companies	3	The substation topside and foundation cannot be designed until the substation's electrical requirements have been established. This requires the turbine choice to have been made. With the substations installed early in the construction phase, developers often need to schedule their construction programmes around the leadtime of the first substation. Significant investment is not required for AC topside supply but is for DC topside supply.
Size of the opportunity	4	Substation spend is a significant portion of CAPEX commitment on a wind farm project. Many other opportunities for oil and gas suppliers exist in the sub-supply such as secondary steel fabrications, walkways, blast protection and accommodation module fixtures.

Table 7 – Diversification opportunities witin substation structures

CASE STUDY – SEMBMARINE SLP

Sub-element: Substation structures

Background: Sembmarine SLP has over four decades of expertise in the design and manufacture of offshore structures for the oil and gas sector worldwide. A subsidiary of Sembcorp Marine, Sembmarine SLP operates a world-class manufacturing yard out of Lowestoft, England. It has an extensive construction area and the capacity to transfer structures up to 6,000tn. The facility also has blasting and paint shops, substantial fabrication workshop capacity and bulk storage, which ensures a smooth transition through the phases of EPC and EPCI contracting.

Challenge: The synergy is high between the manufacture of oil and gas platforms and offshore wind substation structures, but developers only consider suppliers that have a strong marine construction track-record because of the financial penalty from any wind farm downtime. There is no prevalent contracting method with different developers preferring variants of multi-contracting and EPCI models: smaller packages of work are often contracted to drive competition within the supply chain. Substation structure suppliers must be able to work with developers that are aiming to simplify and standardise topside designs; in-house design and value engineering excellence is therefore a real advantage.

Solution: Sembmarine SLP invested in its capability to design, develop, engineer and fabricate offshore wind substation topsides as well as jacket foundations: this allows the company to offer a wide spectrum of capabilities to a sector contracting structures at various levels of integration. "Sembmarine SLP has approached the offshore wind sector with an understanding that the delivery of highly engineered bespoke offshore assets safely, to the highest quality, within budget and on time is paramount. We have built up a comprehensive range of personnel, equipment and procedures to provide the first class engineering support that the offshore engineering industry demands," says Andrew Thompson, Business Development Manager at Sembmarine SLP.

Having all personnel based in-house has allowed Sembmarine SLP to link offshore design and engineering functions to its construction function, which enhances is competitiveness. "We have worked hard to reduce man hours by eliminating interfaces between the various phases of the project including concept design, detailed design, construction and installation," says Andrew.

Sembmarine SLP has approached the offshore wind market with a global outlook and has actively looked to establish overseas partnerships. As a result, the company has signed a MoU with the China Shipbuilding Corporation and the Zhengzhou Institute of Mechanical and Electrical Engineering to cooperate on wind farm substations. "Although the offshore wind energy market in China is in its infancy, its potential is vast. There is a strong pressure to drive down costs in emerging markets and with the help of our partners, we can demonstrate how the experiences learned in the UK can be used to benefit projects in both China and Europe," says Paul Thomson, Managing Director of Sembmarine SLP.

Result: Sembmarine SLP entered the offshore wind sector in 2002 with the design and fabrication of met masts for the Rhyl Flats farm and has gone on to supply offshore structures to five UK offshore wind farms. The latest was the award by Siemens of the Dudgeon substation contract in 2014, which will create up to 300 jobs over 21 months. "One of SLP's main objectives has been to apply its long experience in designing and building offshore platforms for the oil and gas industry to the offshore wind sector. The design of the Dudgeon platform will build on our success with the Thanet substation for Siemens and we hope it will be one of many future offshore substations that we build in Lowestoft," says Paul.

Turbine foundations
Turbine foundations represent a major part of total CAPEX. The technology is chosen based on site features, such as water depth, seabed conditions and turbine size.

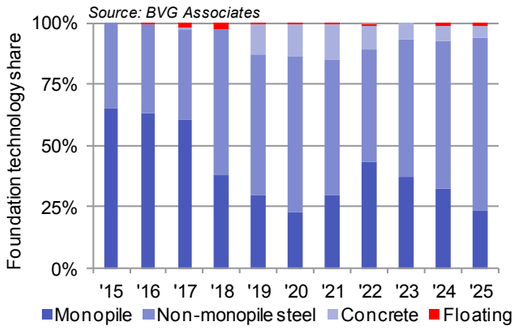


Figure 8 – Forecast market share by foundation type to 2025.

Gravity-bases
With concrete, steel and hybrid options, gravity-base structures (GBSs) can be assembled onshore and installed without the need for piling. This avoids some of the noise restrictions placed on projects to limit the impact on marine mammals.

As of yet, no UK project has used gravity-based turbine foundations, but they have been deployed on the Continent, mostly within shallow, near-shore sites. Their future use is more likely to be as an alternative to jackets at water depths of 40-50m.

Large quayside or dry dock facilities are required with heavy lift capabilities for foundation manufacturing and load-out. Near-shore, shallow water capacity is required for pre-installation storage.

Developers using GBSs prefer local supply for a number of cost and logistical reasons.

Monopile structures
More than three quarters of all installed European offshore wind projects to date have used steel monopile foundations. For this foundation type, there is sufficient manufacturing and installation capacity in the market.

XL monopiles (up to 10m in diameter) have extended the deployable water depth for this foundation type. The use of monopiles is likely to decline as wind farms are built in deeper water and with larger turbines.

Jacket structures
Jacket foundations are cross-braced, welded, space-frame structures. This type of foundation is expected to be the main technology deployed in the next decade, with Scottish offshore projects particularly likely to use them. Both three- and four-legged designs will be used. Four legged jackets have the advantage of a longer track record but three-legged jackets have the advantage of lower fabrication and installation costs.

For orders above 50 units, developers are likely to split supply (and risk) across two or more suppliers. Fabricators supplying more than 80 units annually will need storage capacity and an ability to employ serial manufacture techniques.

Other space-frame designs, such as tripods and tri-piles, have been used on German projects but their future role in offshore wind is likely to be limited.

Floating structures
Floating offshore wind provides opportunities to exploit near-shore deep-water sites at comparable cost of energy to sites using fixed foundations. This technology is still at the pilot stage, but Scotland is at the forefront of global development.

There are three main types of floating offshore wind structure:

- Tension leg platform
- Semi-submersible platform, and
- Spar buoy.

Tension leg and semi-submersible platforms have been widely used in the oil and gas sector. Statoil will use its spar buoy technology for its Hywind project off Peterhead, with the structures to be made in Spain.

The oil and gas sector has helped Scotland develop a dry-dock capability ideally suited to supporting semi-submersible fabrication.

Floating sub-structures enable projects to move into deeper waters with high wind resource where fixed-bottom foundations cannot be deployed. Currently, floating wind farms have a higher cost of energy than fixed but companies that can make a significant impact on cost can gain first-mover advantage in this market.

Criteria	Score	Comments
Oil and gas track record in offshore wind	3	Traditional oil and gas manufacturers such as Bladt, EEW, Sif and Smulders have made the transition to offshore wind. The former TAG facility on Teesside, before its takeover by Bladt and EEW, provided foundations for the Humber Gateway offshore wind farm. Burntisland Fabrications (BiFab) has also produced jackets for the Beatrice demonstrator as well as Alpha Ventus and Ormonde wind farms.
Oil and gas sector synergies	3	UK fabricators have been servicing the oil and gas sector with offshore support structures for over four decades. As a result, the UK has key competencies for manufacturing subsea structures and associated ancillary equipment. This expertise and the supporting infrastructure is highly relevant for offshore wind. All of the foundation types that are being used or being considered by offshore wind developers have been deployed at scale in the oil and gas industry, albeit under different loading patterns. Gravity base structures, semi-submersible platforms and tension-leg platforms have been used in oil and gas for a number of years and the expertise can be directly applied to offshore wind. The critical difference, compared with oil and gas, is the need to refine the design and fabrication of offshore wind structures to enable efficient serial manufacturing.
Appetite from offshore wind	4	Foundation supply offers a good opportunity for increasing local content in some markets, and a new entrant from oil and gas would be welcomed if it has sufficient infrastructure and a good manufacturing track-record. Supply from incumbent suppliers on the Continent to the UK is economical, and there are limited logistical savings from local supply of monopiles and transition pieces. The main supplier of steel for monopiles, Dillinger Hütte, is located in western Germany with close proximity to many existing monopile suppliers.
Potential for LCOE benefit from new involvement by oil and gas companies	4	Innovations in manufacturing to reduce costs are well understood and will contribute significantly to offshore wind lifetime LCOE improvement. Several fabricators have advanced plans to invest in innovative serial manufacturing facilities, but the high cost and uncertain market means that the investment has not been forthcoming. There is a danger that expected LCOE benefits will not materialise through lack of competition.

Table 8 – Diversification opportunities within turbine foundations

Criteria	Score	Comments
Size and timing of investments by oil and gas companies	1	For all foundation types, oil and gas companies are unlikely to make investments in tooling, and such like, to win offshore wind contracts without access to a clear pipeline of contracts. The uncertainty over which foundation type developers will use makes it difficult for oil and gas suppliers to target a specific opportunity. Jackets, in particular, require a large infrastructure investment and it is unlikely that a prospective supplier will be able to invest without multiple firm orders. Concrete foundation manufacturing facilities can be operational 12 months after FID and are not capital intensive in themselves, but the longer term investment in quayside strengthening and channel dredging can make investment difficult. Developers have indicated that it is difficult to place a contract with a company using a facility that has not yet been built. Competitive bidding in an industry with intermittent demand can lead to narrow margins. The risk that this places on manufacturers has been a factor in deterring investment.
Size of the opportunity	4	The production process for monopiles is largely automated therefore job creation potential is limited. The biggest initial opportunity for oil and gas companies may lie in the supply of transition pieces which has a greater demand for fabrication labour than monopile fabrication.

Table 9 – Diversification opportunities within turbine foundations

CASE STUDY – GLOBAL ENERGY GROUP

Sub-element: Turbine foundations

Background: Founded in 2005 and headquartered in Inverness, Global Energy Group's development of the Nigg Energy Park into a leading service and contracting company is one of Scotland's manufacturing success stories. Successful growth has been delivered through strategic acquisitions, organic development and internationalisation, which has led to the group employing more than 3,500 personnel worldwide. The organisation is made up of numerous companies within two main business streams: process and equipment; and marine and logistics. The company has a strong track record in oil and gas, carrying out inspection, repair and maintenance of exploration rigs, subsea vessels, and floating, production, storage and offloading (FPSO) vessels with the full backing of Fortune 500 multinational, Mitsui.

Global Energy's Nigg Energy Park was identified as one of the key sites in the Scottish Government's National Renewable Infrastructure Plan (NRIP), putting it at the forefront of Scotland's efforts to support the emerging offshore wind market.

Challenge: There are a number of challenges facing companies with aspirations of supplying offshore wind turbine foundations. Firstly, the supply of structural tubulars for foundation structures comes from companies in continental Europe and Asia, therefore there are commercial advantages for local fabricators that do not have to manage the uncertainties in exchange rates and international taxation. "We, like many UK manufacturers and fabricators, are competing for offshore wind contracts with fabrication yards in Europe and Asia that have already benefitted from infrastructure investment and are able to serve both the offshore wind and oil and gas sectors," says Alastair Kennedy, Communications Director, Global Energy Group. Challenges for suppliers looking to enter offshore wind include the difficulty of making the right supply

CASE STUDY – GLOBAL ENERGY GROUP

chain connections and addressing wind developers' perception that traditional oil and gas manufacturers are too expensive and do not have the capability to achieve cost reduction via standardised volume foundation manufacturing. Global Energy anticipates that offshore wind is seeking to take 25% out of the cost of a 600-700t turbine foundation.

Solution: Global Energy has invested significantly to attract offshore wind as well as oil and gas customers. A recent investment in a new 180m jetty, an enhanced dry dock, and lay-down and fabrication capabilities in the South Quay has taken total investment in the 70ha Nigg Energy Park to £70 million. "We have invested significantly in our facilities, despite the downturn in oil and gas, as we believe that the growing offshore wind sector can be served in conjunction with the oil and gas sector. We are demonstrating to potential offshore wind developers that we have the infrastructure to manufacture foundation structures in volume," says Alastair.

Global Energy anticipates a strong turbine foundation market beyond 2020, with the bulk of demand being for fixed foundations. Large dry dock capacity is required to service the floating offshore wind market and Global Energy is keen to target the semi-submersible market where local content has the potential to be higher.

Result: Within the UK, Global Energy is leading the way in the manufacture of structures for renewable energy devices, through prototype wave and tidal and wind projects and the company hopes to become the manufacturer of choice within the renewable sector. Global Energy has signed a MoU with Moray Offshore Renewables Limited and has already supplied it with met mast structures. Statoil announced at the end of 2015 that Global Energy has been selected to supply subsea structures for the Hywind pilot park off the coast of Peterhead in Aberdeenshire – the world's biggest floating wind farm. Subsidiary company Isleburn will provide 15 suction anchors to the project to be delivered at the beginning of 2017. The contract will provide work both in the Highlands and in Aberdeen for a number of suppliers. "Isleburn and Global Energy Group have used their experience from the oil and gas sector to land the award of this contract. The oil and gas supply chain has core competencies ideally suited to offshore wind and lessons can be learned to the benefit of both sectors. There is no doubt that the local supply chain and wider economy will benefit from Global Energy and other UK manufacturers securing offshore wind fabrication, installation and maintenance contracts" says Alastair.

Secondary steelwork
Secondary steelwork covers the fabrication of small components within the turbine tower, substation and foundation. A number of areas require secondary steel including cable entry systems, boat landing systems, platforms and rails, sacrificial anodes, air conditioning systems and jacket pile sleeves.

Supply is often sub-contracted via competitive tenders on a project-by-project basis. There is no real requirement for manufacturers to have coastal facilities as in many cases the components can travel by road.

For large volumes, it is advantageous to have at least a final assembly facility with good quayside access.

Most secondary steel demand comes from the foundation. In particular, it is common for monopiles to be designed without a J-tube to reduce cost and alleviate some of the problems with the cable pull-in.

Criteria	Score	Comments
Oil and gas track record in offshore wind	3	Oil and gas companies have been successful in winning work such as Hutchison Engineering. In many cases, these secondary steel companies are active in several sectors, including civil engineering, defence and industrial equipment.
Oil and gas sector synergies	3	There is a high degree of synergy in the types of fabrication used in both sectors. A number of the standards and certifications for supplying offshore marine structures are common. Different load strength requirements for offshore wind structures lead to differences in some areas, for example welding requirements. Further opportunities for oil and gas suppliers further down the supply chain include the manufacture and supply of ancillary equipment such as flanges, cable pull and protection equipment and access systems.
Appetite from offshore wind	2	Appetite for new entrants is limited; items to be supplied are viewed in the main as commodity items and there are a large number of fabricators who are capable and willing to supply.
Potential for LCOE benefit from new involvement by oil and gas companies	2	Secondary steel supply makes up a small portion of total lifetime spend and as raw material makes up the bulk of the cost — there is limited LCOE contribution potential.
Size and timing of investments by oil and gas companies	4	Oil and gas companies are unlikely to have to invest significantly in infrastructure. Investment in skilled labour for any required offshore wind specific manufacturing requirements is likely to be the element with the longest lead-time. Supporting secondary steelworks is a good entry point for organisations looking to gain traction in larger foundation manufacture.
Size of the opportunity	2	The lifetime spend as a proportion of an individual project is small, therefore larger organisations may need to target multiple projects to justify any investment.

Table 10 – Diversification opportunities within secondary steel

CASE STUDY – HUTCHISON ENGINEERING

Sub-element: Secondary steel

Background: Founded in 1979, Hutchinson Engineering has designed and manufactured steel structures for various industries for over 35 years, including telecommunications, transport, oil and gas, and pharmaceuticals. The company entered the renewable sector in 2007, supplying structures for onshore wind turbines, and invested £5 million in a new 4,500m2 site in 2014 to further expand its wind manufacturing capabilities.

Hutchinson Engineering has state-of-the-art equipment for laser profiling, pipe cutting, plate rolling, blasting and painting giving the company full capability to design and fabricate anything from the smallest bracket up to complex free-standing structures and towers.

Challenge: There is relatively little intellectual property in secondary steel supply and it is therefore a highly commoditised sub-element; many suppliers, therefore, have the potential to supply meaning that value for money is a key consideration when awarding projects. There is a cost in developing new suppliers of secondary steel, therefore, this can mean that customers retain existing suppliers unless there are significant logistical or cost benefits.

Solution: Hutchinson Engineering has invested a significant amount of time and effort to ensure that it has the capability to supply steelwork to the offshore wind industry. Firstly, the company has discovered that offshore wind customers are looking for relevant manufacturing accreditations to be in place before a contract award can be made. "We already had our ISO 9001, 14001 and OSHAS 18001 accreditations in place but we have had to work hard to gain full Achilles and FPAL status – these qualifications are pre-requisites for supplying hardware to the offshore wind sector" says David Oswin, Business Development Manager at Hutchinson Engineering. Secondly, the company has worked hard to develop a high level of local content. The requirements of the UK Government's supply chain plan concept places a heavy emphasis on stimulating competition, innovation and skills within the indigenous supply chain and Hutchinson Engineering has worked with this premise in mind when approaching the sector.

Realising the need within the sector for cost reduction, Hutchinson Engineering has developed a number of optimised manufacturing techniques. "Building upon our proven capabilities, we have enhanced our automated cutting and profiling services to develop a lean manufacturing plan for competitive volume fabrication for the offshore secondary steel market in particular. We dedicated a year to establishing our workshop facility, improving our technical capabilities, talking through specifications with clients as well as sending many of our workforce on quality control training workshops," says David.

Result: In 2015, Hutchinson Engineering was awarded a contract by Smulders to supply 67 sets of internal and external access ladders, cable ladders, rescue support frames and platforms for the Dudgeon offshore wind farm – a contract worth over £500k for the company.

CASE STUDY – HUTCHISON ENGINEERING

Supplying this equipment to Smulders, this contract will be the first export contract for Hutchinson Engineering and the first instance of Smulders sourcing secondary steel directly from the UK. The company worked through several rounds of capability reviews and audits before securing the contract. "Combined with the required offshore accreditations, Smulders identified Hutchinson Engineering as having the skills, experience and knowledge to deliver a quality product safely. Smulders's auditors also felt that our senior management displayed the necessary drive to succeed and were prepared to initiate further in-house training to guarantee success," says David.

Hutchinson Engineering is able to demonstrate to offshore wind customers a core competence in production control and management systems gained from experience in supplying the oil and gas, telecommunications and even the onshore wind market. "Our experience in supplying towers and fixtures to the onshore wind market has definitely helped us get a foot in the door within the offshore wind sector. Winning this contract has allowed us to recruit additional staff and invest further in training. Coupled with our new quayside facilities, we are hopeful that we have the infrastructure and staff to make offshore wind secondary steel supply a significant part of our future manufacturing portfolio," says David.

Installation and commissioning

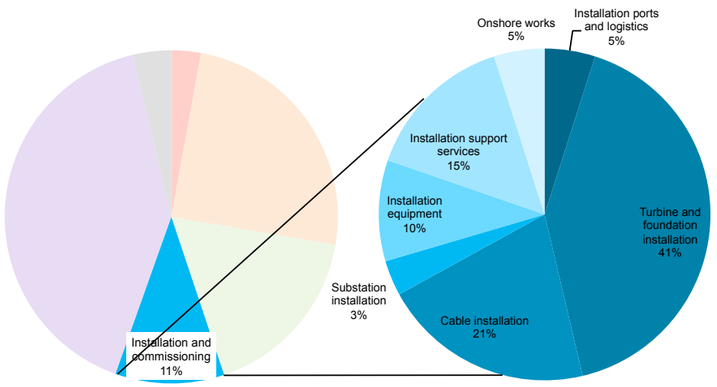


Figure 9 – Breakdown of the costs within the installation sub-element

Although many of the personnel involved in installation work have a background in oil and gas, few oil and gas companies have a track-record in turbine and foundation installation. The vessels used for offshore wind are now bespoke and often high-specification jack-up vessels built in the Gulf states or east Asia. The main opportunities for oil and gas companies lie in installation equipment and support services, to engineer efficient offshore solutions for a range of installation activities. The participation of these organisations in cost reduction programmes is expected to be high.

The barges used to float substations out to the wind farms can service multiple sectors. Substations are then installed at sea using heavy lift vessels. Substation installation often forms part of the substation supply contract. Seaway Heavy Lifting is a subsidiary of Scottish based Subsea7 and has installed a significant number of offshore wind substations.

There is no significant opportunity for oil and gas suppliers to provide onshore connection services as synergies are low. Electrical connection and onshore substation works are supported by a number of well established electrical and construction experts.

Some developers are keen on negotiating framework agreements covering multiple projects. This not only secures supply of a vessel that meets the needs of their project pipelines, but also allows learning and optimisation across multiple projects.

Installation ports are normally selected based on proximity to the wind farm. Unless a port is close to a number of sites, it is difficult to justify infrastructure investment for a single project lasting as little as three years. Return on investment can only be justified if long-term OMS activity can be based at the port.

Cable installation, installation equipment and installation support services are the best opportunities for oil and gas suppliers and are examined in more detail in the remainder of this section.

Sub-element	Lifetime spend for 500MW wind farm		Oil and gas opportunity
Installation ports and logistics	0.5%	£30 million	
Turbine and foundation installation	4.4%	£245 million	
Cable installation	2.2%	£120 million	
Substation installation	0.4%	£20 million	
Installation equipment	1.0%	£60 million	
Installation support services	1.6%	£90 million	
Onshore works	0.5%	£30 million	

Table 11– Summary of installation opportunities

Cable installation

The trend towards EPCI contracting for cable installation should create opportunities for large oil and gas suppliers with relevant experience. A number of contractors specialise in array or export cable-laying (depending on the strengths of their fleet) and some undertake burial only. Array cabling in particular has been a significant challenge in offshore wind.

The cable pull-in at the turbine is a complex task and may be performed over 100 times at a wind farm. Any difficulties with the equipment or the foundation design can therefore have a major impact on the project schedule. There are opportunities for oil and gas companies to participate in R&D programmes that develop new solutions for the connection of the cable at the tower base or that develop innovative subsea connectors.

Achieving the specified cable burial depth can be costly and time consuming. Installation contractors report that many problems can be avoided with early engagement in a project and that inadequate sea bed surveys and inflexible burial requirements have added risk to projects.

As the offshore industry has matured, price is less commonly the dominant factor in contracting. Despite concerns from some installers that price determines the choice of contractor, developers have learnt from previous projects and there is now an increased focus on performance to reduce risk and overall cost.

Criteria	Score	Comments
Oil and gas track record in offshore wind	3	A number of oil and gas suppliers have successfully diversified into offshore wind including Canyon Offshore for trenching works, DeepOcean, Van Oord and VMBS. Cable manufacturers such as Nexans and Prysmian operate in both sectors. They have the capability to install cables and will offer this service if the client wants a turnkey supplier. Cable installation is a highly specialised and competitive market and companies such as Reef Subsea, SubOcean and Technip Offshore Wind have experienced financial difficulties or decided to exit from the offshore wind sector.
Oil and gas sector synergies	4	Oil and gas suppliers have a solid track-record in cable installation. One of the key areas in which new entrants would have to become familiar is the pull-in of cables and the much larger geographical installation areas.
Appetite from offshore wind	4	Developers and insurers view cable installation as a high-risk operation and are keen to attract oil and gas expertise to mitigate the perceived high risk in areas such as cable route engineering, burial innovation and dynamic analysis. Cable installation has long been an area of concern for the industry due to the number of problems encountered and developers have cited the lack of credible suppliers as a major issue. The emergence of well-backed companies such as Jan de Nul and Siem Offshore has eased these concerns. The market entry of Fugro has been facilitated by E.ON, evidence of the appetite within certain developers.
Potential for LCOE benefit from new involvement by oil and gas companies	2	Opportunities for cost savings in cable installation are limited. The downturn in oil and gas installation activities may reduce vessel day-rates and this can contribute benefit to offshore wind LCOE.
Size and timing of investments by oil and gas companies	4	Investment is unlikely on the basis of an individual project, so companies have to plan investments based on a pipeline of work. Framework agreements that allow access to multiple projects are therefore commonplace.
Size of the opportunity	2	Cable installation makes up a small part of lifetime spend and is concentrated across a short period of time within the CAPEX life cycle.

Table 12 – Diversification opportunities within cable installation

CASE STUDY – DEEPOCEAN

Sub-element: Cable installation

Background: DeepOcean was established in 1999 to provide high quality equipment and subsea services to the telecommunications and oil and gas industries globally. With a presence in UK, Norway, Holland, Singapore, Mexico and Brazil, the company today has a fleet of specialised vessels that enables it to offer a breadth of services across survey and sea bed-mapping, subsea installation, sea bed intervention, inspection and repair, and decommissioning.

Challenge: Offshore projects are increasingly funded by third-party investors and the subsequent focus on lowest price and risk can be a difficult obstacle to navigate. Offshore wind cable installation and tower pull-ins need to be done very quickly, therefore methods need to be developed to achieve this. "The pioneering phase of offshore wind cable installation is ending; companies must learn from projects and apply improvements to subsequent projects to help improve LCOE", says Andy Readyhough, Senior Business Development Manager at DeepOcean.

DeepOcean has encountered a number of differences in serving the offshore wind sector compared to oil and gas. DeepOcean realised early that offshore wind developers were keen to work with supply partners that can offer a range of services. As a result, DeepOcean developed expertise to support a number of areas of offshore wind including engineering and design, route optimisation, geotechnical support, project management and feasibility studies. "Upon entering the sector, it became evident that offshore wind customers valued our front-end engineering and design capabilities. With this being part of our core skills, this gives us a significant competitive advantage," says Andy.

Solution: DeepOcean has invested significantly in cable installation vessels, allowing flexible array and export cable stowage and deployment via integrated burial tools. To complement its installation capabilities, DeepOcean has established the world's largest fleet of high technology marine trenching and burial equipment, including jet trenching ROVs, ploughs and mechanical trenchers. "We realised early that servicing the offshore wind sector required us to invest in new customised vessels and to upgrade our existing equipment – to do this, we needed to be sure that there was a pipeline of projects," commented Andy.

Results: DeepOcean has become a trusted supply partner for a number of offshore wind developers and is often involved in initial FEED studies and is asked to give input on first principles of how to install and protect cables. DeepOcean has brought its many years of innovation in tool and deployment solutions to offshore wind and this has been the backbone of its success. DeepOcean has cited early customer engagement and clear value proposition definition as critical success factors. "We have found that engaging with customers at the design stage significantly reduces the number of Scope of Work redefinitions. If you are a company that can offer high calibre engineering support, you can more than succeed in offshore wind in UK and beyond ", says Andy.

DeepOcean has developed an impressive renewables track-record across Europe having installed over 800km of power cable and ancillary equipment on ten projects. "Diversification into offshore wind was a natural step for DeepOcean. The synergies with our core competencies in oil and gas and telecommunications meant that we believed we could bring innovative expertise to a sector growing at pace while at the same time looking to dramatically reduce cost", says Andy.

Installation equipment
Installation equipment is used for:

- Moving and loading components on the quayside
- Securing components in transit, including sea fastenings and blade racks
- Handling and installing foundations, including piling templates, pile handling tools, piling hammers and cable installation equipment including carousels, tensioners, remotely operated cable trenching and, burial tools and cable retrieval tools, and
- Turbine installation, including cranes, yokes and hook stabilisation tools, and turbine access systems.

Sea fastenings, blade racks and pile handling tools and equipment are designed and manufactured for specific projects, although using equipment for multiple projects can save significantly on mobilisation and demobilisation time.

Certain pieces of equipment are better to be rented than procured and in some cases the equipment is operated by a third party.

Some equipment is bought by the main installation contractor and permanently or semi-permanently installed on a vessel. Examples of this include cranes and cable handling equipment.

Criteria	Score	Comments
Oil and gas track record in offshore wind	4	Oil and gas companies have been successful in supplying the offshore wind industry, with companies such as Acteon and IHC making good in-roads within the sector. Examples of Scottish companies include Aquatic Subsea (part of Acteon), Caley Offshore and Sparrows.
Oil and gas sector synergies	4	There are strong synergies because much of the equipment is bespoke and supplied in low volumes. Cable installation equipment and services such as diving support, cable protection, marine engineering, carousel supply and handling equipment are sub-elements already supplied by oil and gas companies.
Appetite from offshore wind	4	There is no shortage of suppliers, but the offshore wind sector would welcome innovative solutions that can reduce vessel use and bring forward power generation.
Potential for LCOE benefit from new involvement by oil and gas companies	4	A significant area of promise is vibro-piling, where sub-marine noise levels can be significantly reduced whilst piling speed and potentially lower fabrication costs can be realised. Offshore turbine lifts, particularly for the blades, are sensitive to high wind speeds. Solutions are under development but there is further scope for innovation. For deep water sites, existing cable tensioning technology may be inadequate as the current approach is likely to require large equipment that will take up a significant amount of deck space.
Size and timing of investments by oil and gas companies	4	The lead time for most pieces of equipment can be accommodated within the project lifecycle, although there has been strong demand for large piling hammers.
Size of the opportunity	2	The total available market is only a small percentage of CAPEX but a significant proportion is accessible to oil and gas suppliers.

Table 13 – Diversification opportunities within installation equipment

CASE STUDY – W3G MARINE

Sub-element: Installation equipment

Background: W3G Marine is an Aberdeen based company established in 2010 by a group of oil and gas marine and subsea experts seeking to harness opportunities within the growing offshore wind sector. W3G Marine has experience of building a fleet of complex offshore construction vessels and delivering complex subsea and marine projects, and has set out to design, control and manage heavy lift construction vessels with the ability to safely and efficiently install offshore wind turbines and foundations. "Bringing the OWTIS™ vessel concept to market was always considered a long term play. We are determined to share the valuable knowledge gained in the oil and gas industry to bring experience and innovation to offshore wind." commented Alan West, CEO of W3G Marine.

Challenge: W3G Marine realised that entering offshore wind can be challenging, especially for the supply of complex and expensive vessels to deploy offshore structures that are evolving at pace. In order to gain a short-term foothold in the market, W3G Marine decided to target the installation equipment market with a particular focus on delivering step-change innovation.

Solution: W3G Marine has developed the HyrdoNAS™ underwater noise mitigation concept. The company identified a unique solution which uses a versatile, durable and adaptable fabric that is much cheaper than existing solutions. The barrier can be pre-installed on a pile and the solution reduces deployment time and associated cost. Starting with the principle of having zero down-time between installations, W3G Marine worked backwards to invent a game-changing solution which offers installers an innovative and effective low cost piece of installation equipment. "The unique feature of our system is that it can be easily tailored to suit any project demands such as pile size, water depth and installation method. We are confident that by engaging with the client and offshore installation contractors at an early stage we can develop a bespoke, reliable solution at a low price," commented John Giles, Technical Director of W3G Marine.

Results: W3G Marine was successful in securing support from the Scottish Enterprise Innovation Fund. In partnership with its expert acoustic partner, EATEC, they have taken the HydroNAS™ concept from initial pool trials, to harbour trials in Dundee in 2013, and through to sea trials in 2015. Supported by offshore wind developer Vattenfall and installer GeoSea, the sea trial showed that the technology reduces piling noise by about 40%, better than any solution on the market. "From the outset, we have been working with developers and installation contractors to ensure the system fulfils their needs and expectations. Our focus has been on safety, minimised main installation vessel downtime and reliability." commented Charlie Whyte, CFO.

Having now proven the concept, W3G Marine is commercializing HydroNAS™ with a view to full-scale deployment in late 2016. "The offshore wind industry has been very supportive and encouraging in the development of HydroNAS™. There is a definite appetite for robust, simple and cost-effective solutions in this new market. We are ready to deliver them," commented Alan. Oil and gas suppliers seeking to enter the sector must clearly understand what they can offer the sector and their competitive advantage and unique selling points. "Introducing disruptive innovations to a maturing industry, such as offshore wind, can be a risky and timely process so we have maintained a presence in the oil and gas arena until our concepts are fully adopted by the wind industry. Do not expect instant gratification," added Alan.

Installation support services
Installation support services are made up of a number of diverse elements:

- Cable pull-in
- Cable route clearance
- Certification
- Crew and safety vessels
- Diving
- Electrical termination
- Grouting
- Health and safety
- Insurance
- Marine consultancy
- Marine logistics
- Provision of personnel
- Port operations
- Subsea surveys
- Weather forecasting, and
- Removing unexploded ordnance.

Responsibility for contracting these services can lie with either the developer or the main installation contractor.

Some of these services have developed specifically to meet the needs of the offshore wind sector and many of them are delivered by SMEs.

Criteria	Score	Comments
Oil and gas track record in offshore wind	4	Oil and gas companies have been successful in winning offshore wind installation service work. Notable examples are 3sun, Ecosse Subsea and ROVOP.
Oil and gas sector synergies	4	Oil and gas skills can be readily applied to offshore wind. An important challenge is how best to adapt oil and gas best practice for the new sector. A key difference is the number and area of offshore installations; oil and gas suppliers must clearly communicate how they can evolve their services to meet this challenge.
Appetite from offshore wind	4	The offshore wind sector values the experience gained from oil and gas companies that can understand and use best practice from actual experience servicing offshore wind.
Potential for LCOE benefit from new involvement by oil and gas companies	4	Oil and gas service innovations can reduce risk and installation times. Significant cost savings can be made by reducing the time needed for expensive installation vessels.
Size and timing of investments by oil and gas companies	4	Oil and gas companies may need to invest in new equipment but otherwise investments will be in personnel and capacity to meet demand.
Size of the opportunity	2	The total available market is only a small percentage of CAPEX but a significant proportion is accessible to oil and gas suppliers.

Table 14 – Diversification opportunities within installation support services

CASE STUDY – FOUNDOCEAN

Sub-element: Installation support services

Background: With headquarters in Marlow, England, a European Offshore Service Base in Livingston, Scotland, and offices in Houston and Dubai, FoundOcean is the world's largest dedicated offshore grouting company. FoundOcean has serviced the global oil and gas market for almost 50 years, providing world-class solutions for asset construction grouting as well as asset life-extension including freespan correction, pipeline rehabilitation and jacket strengthening maintenance and repair.

Challenge: Offshore wind developers need support from service providers throughout the installation phase and for maintaining asset integrity throughout its lifetime. Prospective supply partners must have a track-record of operating in harsh marine environments. "Our entry into the offshore wind market was extremely fortuitous," comments Andrew Venn, FoundOcean Sales Director. "A long term oil and gas customer was supporting a group company on a project, and approached FoundOcean understanding that the scope of work would benefit from our experience and capabilities," says Andrew. FoundOcean discovered that offshore wind was a market that offered the company a diversification opportunity right on its doorstep and that there was a gap in the market for credible service providers to exploit. "We saw offshore wind as a market trying to encourage competition with the aspiration of delivering innovation in the supply of goods and services – aspirations which match the FoundOcean guiding principles," comments Andrew. Having supported installation of the Arklow Bank offshore wind farm in 2003 and Ormonde in 2010, FoundOcean realised that the product it offered fell short of what certain projects required.

Solution: FoundOcean invested significantly in product development for offshore wind and partnered with a multinational supplier, BASF, to develop an innovative new grouting solution. "BASF had engineered a product specifically for offshore wind but at that time had no credible route to market. Both parties quickly discovered that this alliance was the perfect partnership: two very experienced companies with aligned goals that naturally fulfilled a significant gap in the market. The result was a market proposition that combined operational knowhow with the latest in material design to an offshore wind sector that was looking for improvements in productivity, safety and reliability," says Andrew.

Result: Since 2010, FoundOcean has gone on to work on offshore wind projects across Europe and it now serves the oil and gas and offshore wind industries on a 50:50 basis. FoundOcean has noted a number of differences unique to the offshore wind sector:

Tendering process
- Can be protracted
- Extremely competitve
- Pre-qualification may be required
- Early budgetary pricing may be requied

Relationships
- Supply chain fluidity – customers move across tiers on a project basis
- Only as good as your last job – news travels fast
- Building and maintaining relationships across projects is key

Enabler support
- Excellent support from Scottish Government and enabling agencies
- Level if support depends on industry-wide LCOE reduction

Communication
- Project transparency better than in O&G
- Conferences and supply chain events a useful source of information

Competition
- Very healthy – strong European supply chain
- Strong competition stimulatesinnovation

As a cautionary note to other companies looking to join the sector, FoundOcean has discovered that the biggest risk when entering offshore wind is in trying to predict the future shape of the industry with any great degree of certainty. "The supply chain continues to work hard tendering and planning against projects that are not fully financed. Our advice is to not look too far into the future and not to expect great levels of certainty on those projects that have not reached their final investment decision. However, get it right and offshore wind can be a long-term part of a company's strategic vision with excellent global prospects," says Andrew.

Operation, maintenance and service

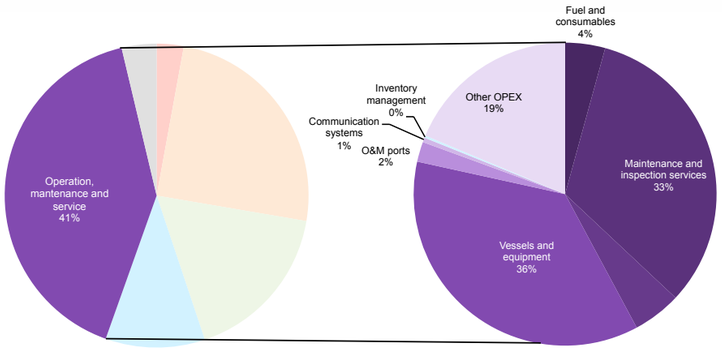


Figure 10 – Breakdown of the costs within the operation, maintenance and service sub-element

Maintenance and inspection services present the greatest opportunity for oil and gas suppliers seeking to diversify. Opportunities exist for companies to supply fuel and consumables to companies servicing offshore wind assets but the labour content is low and there is no inherent advantage if companies come from an oil and gas background. The opportunities for oil and gas companies within maintenance and inspection services are examined in more detail in this section.

Opportunities for the supply of vessels and equipment for supporting operations will be limited initially because oil and gas companies have a limited track-record in offshore wind. Most maintenance vessels are owned and operated by specialist companies. Investment in large vessel capacity needs careful management as manufacturing lead times can be over three years. There is some uncertainty over the OMS strategies adopted by developers as projects are built further from shore. Their supply chain requirements will become clearer later this decade as maintenance strategies evolve and far-from shore wind farms come on line.

Specialised OMS clusters are likely to develop over time to support major repairs and provide storage capacity for large replacement components such as blades and gearboxes. There is little benefit of combining offshore wind port requirements within existing oil and gas service hubs.

Communication systems will be required in greater numbers as offshore marine activity picks up pace. Oil and gas companies are not necessarily better placed than specialist suppliers from other sectors to take advantage of the opportunities.

Oil and gas suppliers have very limited experience in the provision of offshore wind logistics expertise. However, optimised offshore coordination can contribute significantly to LCOE reduction and specialist oil and gas suppliers may find opportunities as deployment activities increase across Europe.

Sub-element	Lifetime spend for 500MW wind farm		Oil and gas opportunity
Fuel and consumables	1.7%	£97.1 million	
Maintenance and inspection services	13.4%	£744.4 million	
Vessels and equipment	14.8%	£825.5 million	
O&M ports	0.9%	£48.6 million	
Communica-tion systems	0.2%	£11.2 million	
Inventory management	0.1%	£4.6 million	
Onshore works	0.5%	£30 million	

Table 15 – Summary of operation, maintenance and service opportunities

Maintenance and inspection services

Maintenance and inspection covers a range of activities:

- Blade inspection and repair
- Cable fault detection and repair
- Communication services
- Foundation health monitoring and repair
- Health and safety and training services
- High voltage maintenance
- Turbine maintenance, and
- Wildlife survey and environmental services.

Apart from turbine maintenance, most services do not involve day-to-day activity on site. With the exception of the service agreements with the OEMs, specialist SMEs provide many of the services. Some of these suppliers have grown specifically to meet demand from offshore wind. Increasingly, hubs such as Barrow, Grimsby, Mostyn and Ramsgate, which service several wind farms, are attracting these service providers as they grow.

In the onshore market, wind farm services are offered as a one-stop shop. This has not happened yet in offshore wind to the same extent, partly because many assets are still under warranty and the skill requirements are more diverse. Broad service providers are likely to emerge as the market matures and an increasing proportion of turbines are out of warranty.

Criteria	Score	Comments
Oil and gas track record in offshore wind	4	Oil and gas suppliers have had success in maintenance and inspection services with examples including Briggs Marine, 3Sun, Hughes Sub Surface Engineering, Sea Energy and Sub C.
Oil and gas sector synergies	4	Oil and gas suppliers have a vast amount of experience in maintaining assets in the North Sea and synergies in terms of defect detection, planned maintenance and asset repair are extremely high. Oil and gas offshore safety standards and maintenance practices are highly transferrable to offshore wind. A strong oil and gas service supply chain has been developed over a number of years, and a number of specialist disciplines are highly transferrable.
Appetite from offshore wind	4	OMS is likely to be carried out by the original manufacturers while assets are under warranty but developers may look to take in-house or outsource to cheaper third party supply partners in the future, and oil and gas suppliers have a strong track-record in this area.
Potential for LCOE benefit from new involvement by oil and gas companies	4	Offshore wind asset uptime is of primary importance, therefore efficient servicing and innovative repair techniques can contribute significantly to LCOE reduction. Innovative approaches from the oil and gas sector will be welcomed by offshore wind asset owners.
Size and timing of investments by oil and gas companies	4	Bespoke investment for offshore wind is small and capacity can be created incrementally on a short lead time as contracts for a particular project are secured.
Size of the opportunity	4	Lifetime spend is high and over 25 years for a particular project. For this reason, this is one of the most attractive sub-elements for oil and gas companies to target.

Table 16 – Diversification opportunities within maintenance and inspection services

CASE STUDY – 3SUN GROUP

Sub-element: Maintenance and inspection services

Background: 3sun Group was established in 2007, initially to provide control and instrumentation services to the oil and gas sector. Today, the company has six divisions, employing over 300 people, with facilities in Great Yarmouth, Aberdeen and Denmark. In 2010, the company acquired Dawson Energy, an industry leader in delivering installation and maintenance of onshore and offshore wind turbines, and has since grown its presence significantly within the renewable sector. The Group has recently acquired AID Industrial, a specialist training provider, to further strengthen its rope access training and equipment expertise. 3sun Group CEO, Graham Hacon said, "The offshore wind sector was a growing market on our doorstep and we saw it as an ideal opportunity to offer our core competence expertise to developers and tier one OEMs."

Challenge: Providing highly trained staff and expertise for offshore wind installation has been 3sun Group's core business since the boom in offshore wind, but the company has had to work hard to develop new capabilities. Graham said "We realised quickly that there were skills gaps in this new industry and customers prefer to procure multiple services from one service provider. For us, it was important to get a foot in the door and to prove ourselves." The need for maintenance of offshore wind assets will increase as deployment grows: 3sun Group has realised that by offering optimised maintenance whereby multiple tasks are carried out during one trip to a turbine, uptime can be significantly improved. To do this, staff must have a wide area of skills. Graham added "The key to success is working with customers to understand assets and equipment so that these skills can be created within our team. Health and safety is a key consideration and we have seen a market need for offshore training, which we have been keen to exploit."

CASE STUDY – 3SUN GROUP

Solution: Listening to what offshore wind customers need has resulted in 3sun Group establishing an inspection division offering a single point of contact for statutory inspection services, delivering asset and equipment verification. Teams of multi-disciplined technicians can carry out inspection and maintenance on lifting equipment and pressure systems, non-destructive testing and retrofits amongst other tasks. 3sun Group is also uniquely placed to offer engineering and consultancy support as it has been able to develop bespoke solutions to many recurring challenges: value-add engineering support is offered for mechanical and electrical design, failure mode analysis and heavy lift plans and deck layout designs. "Having grown with the industry, we can pinpoint areas of improvement and help our customers develop real cost effective solutions. The key to this lies in our ability to understand our client's needs and an ability to tailor our solutions accordingly".

3sun Group has developed a capability to supply turbine parts and components. With collaborations in place with OEMs whose products are used offshore such as fall-arrest systems, cranes and generators, 3sun Group can offer tailored technical advice and supply chain management across sourcing, procurement, installation and servicing of key components.

Results: With up to 40% of total lifetime spend committed to offshore wind asset operation across a 25 year lifetime, operations and maintenance support is set to become one of the major growth revenue streams for 3sun Group. Using its strong oil and gas heritage, 3sun Group can offer offshore wind customers certified technicians and engineers, fault finding and repair, support of major component replacements – such as blades or generators – and expert management of annual planned maintenance programmes. 3sun Group has learned to refine servicing strategies to incorporate highly competent, multi-skilled and experienced labour solutions coupled with innovative engineering and sharp logistics aimed at increasing asset generation levels. Graham commented "Our services need to be adaptable for each client. To succeed in offshore wind, we have learned that our service must eliminate costs for the customer through faster deployment and more comprehensive servicing".

Offering advice to oil and gas companies looking to diversify into offshore wind, Graham commented, "New market entrants must have a clear idea of what their core competence is and how to articulate their value proposition to customers. Companies must show how they can help customers improve asset efficiency or reduce risk and cost if they are to succeed in offshore wind."

Decommissioning

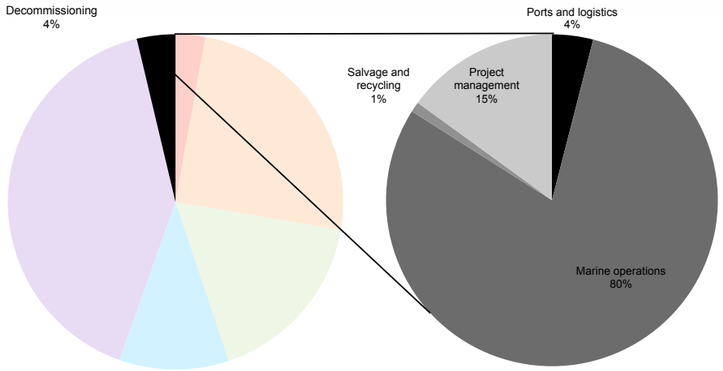


Figure 11 – Breakdown of the costs within the decommissioning sub-element

Only one small offshore wind farm has been decommissioned and the strategies for large-scale projects are highly uncertain.

Developers are required to submit high level decommissioning plans from the outset – requirements are in line with the statutory decommissioning scheme covered in the Energy Act 2004.

Although there is little regulation specific to the decommissioning lifecycle stage of offshore wind installations, it is anticipated that offshore regulations will be applied in a similar manner as oil and gas licensing and environmental protection regimes.

Unlike offshore decommissioning in the oil and gas industry, where service providers have accumulated sufficient experience to enable them to rapidly carry out decomissioning works, decommissioning offshore wind turbines is expected to be more complex given the larger number of units spread across a bigger geographical area.

On optimal sites, owners may choose to "repower" the wind farm at the end of life. This is likely to involve the use of larger turbines and this means that because of the mechanical loads and increased spacing to avoid wake effects, the turbine locations will change. Only the transmission assets are likely to be retained.

Oil and gas suppliers are likely to be well placed to provide decommissioning services, but there will not be significant activity before 2025.

Sub-element	Lifetime spend for 500MW wind farm		Oil and gas opportunity
Ports and logistics	0.1%	£8 million	
Marine operations	3.0%	£165 million	
Salvage and recycling	0.1%	£2 million	
Project management	0.6%	£3 million	

Table 17 – Summary of decommissioning opportunities

Market growth

By the end of 2015, around 4,500 offshore wind turbines and 12GW of offshore wind capacity was installed globally, with a further 3.8GW due to be installed in 2016. By the end of 2025, a further 7,000 turbines and 46GW additional capacity is forecast to be deployed. Between 2016 and 2025, the global capital and operational expenditure on offshore wind is forecast to be in the region of £210 billion.

Most countries target near shore deployment at the early stage of national development. Where there are few suitable shallow near-shore sites, floating turbines may be deployed from the outset.

As shown in Table 18, this guide grades the top seven global markets as red-amber-green in terms of:

- Market size
- Openness of market to overseas supply
- Political support, and
- The complexity of the planning and regulatory environment.

Criterion	Red	Amber	Green
Installed capacity by the end of 2025	←5GW	Between 5GW and 10GW	→ 10GW
Openness of the market	Generally closed to overseas suppliers	Open but with local content re-quirements	Open with few restrictions
Political support for offshore wind	Low	Moderate	Strong
Consenting and regulatory environment	Difficult and slow	Moderate complexity and lead times	Straight forward and fast

Table 18 – Criteria for assessing different markets

Europe
Of the 11GW of capacity currently commissioned in Europe, almost half is located in UK waters, about 30% in German waters with the remaining capacity in other parts of the North Sea and Baltic Sea. In 2015, the offshore wind industry contributed 1.6% of Europe's total electricity generation, and 6.9% of Europe's renewable electricity generation.

Europe will remain the dominant market for offshore wind until at least 2025.

UK

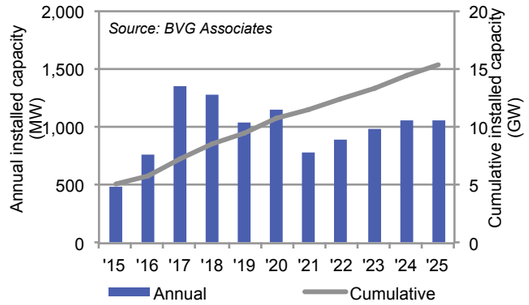


Figure 12

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

The UK is the world leader in offshore wind with 5.1GW installed by the end of 2015. This is expected to rise to 10GW by 2020 with capacity reaching about 15GW by 2025.

Although the UK adopts EU open market rules, the Government requires project developers to provide a supply chain plan demonstrating their commitment to UK innovation, skills and competition in advance of applying for a Contract for Difference (CfD) — the UK's main renewable energy funding mechanism. This is widely interpreted as a signal that developers must support the UK supply chain; however, UK suppliers have so far secured a disappointing portion of work, particularly for CAPEX spend items. Regular reporting of UK content is carried out by RenewableUK.

In order to develop an offshore wind project in the UK, developers need to secure a lease from The Crown Estate or Marine Scotland, for projects in Scottish territorial waters. Once a lease has been secured, an application can be made for a CfD, which tops up the wholesale energy price to an agreed value. CfD allocation is a competitive process where sealed bids based on the cost of electricity for the project are submitted. The next CfD auction will be in autumn 2016 and a further two are planned before the end of 2020.

Most UK planning applications have been successful with most serious challenges concerning the impact on bird populations.

The UK regulator, Ofgem, has decided that transmission assets should be owned separately from the generation assets. Typically, developers build the transmission assets before selling to third parties, which overcomes the risk of stranded assets (an asset with no grid connection).

Germany

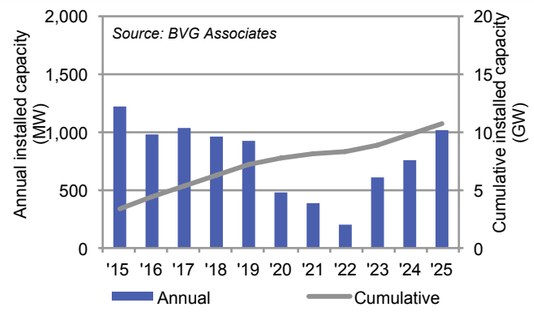


Figure 13

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

Germany had 3.4GW of offshore wind capacity installed at the end of 2015. A further six projects are planned for commissioning by 2020, bringing the total capacity to 7.6GW. The German government hopes to reach 11GW by the end of 2025.

The German market adopts EU open market rules. It already has a strong supply chain in offshore wind with experienced fabricators such as Ambau, EEW and Steelwind Nordenham; cable suppliers such as General Cable and NKT, and turbine manufacturers Adwen and Senvion. The strength of the supply chain means German companies tend not to source overseas for anything other than offshore engineering. There has been some success for UK companies including JDR Cables, MPI Offshore and Seajacks.

The current German government generally favours renewable energy with renewable electricity targets set for 2020 and 2050, with offshore wind a particular focus.

Germany has announced plans for a one-off auction — likely to be in late 2016 — for projects to be constructed in the early 2020s. No further auctions have been announced, raising concerns that failing bidders will leave the market due to a lack of visibility of future projects. A central government body will pre-develop some sites to ensure suitability before opening the tender process.

German policy is for transmission operators to build and operate the transmission assets. Historically, this approach has led to project delays and turbines being stranded without a transmission link, but this issue has now been resolved.

Netherlands

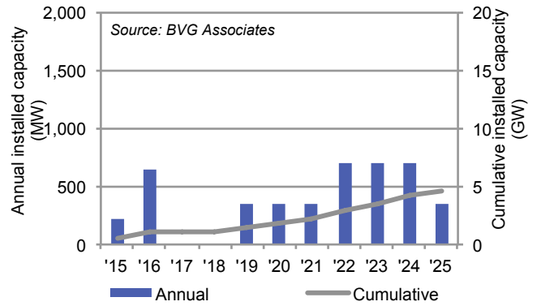


Figure 14

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

The Netherlands had nearly 500MW of offshore wind capacity installed at the end of 2015. Further projects are planned by 2020 bringing total capacity to 2GW. In 2015, the Dutch government announced ambitious plans for offshore wind and it is now anticipated that the Netherlands will have an installed capacity of 4.7GW by the end of 2025.

The Dutch Government has announced three offshore wind zones, which will be tendered annually in 700MW areas for the next four years. Winning bidders will then have four years to install and commission their projects with all zones planned to be operational by 2023.

As part of the European Union, the Dutch market is open to European suppliers on an open market basis. The Netherlands already has a strong supply chain in offshore wind, utilising assets and expertise of major dredging companies. Key companies include offshore contractors Boskalis, Seaway Heavy Lifting, Van Oord and VBMS as well as fabricators such as Cofely Fabricom, Keppel Verolme and Smulders. Competing companies from outside the Netherlands may find it difficult to access the market in these areas of supply.

France

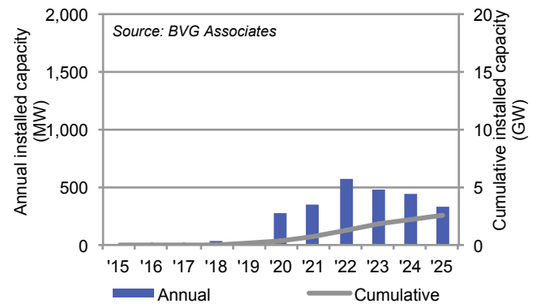


Figure 15

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

France had no offshore wind installed capacity at the end of 2015. Several demonstration projects are expected to be installed in 2016, including EDF's 2MW floating foundation VertiWind demonstration project. Six commercial projects, with potential capacities exceeding 400MW each, were tendered in two rounds in 2011 and 2013. The installation of the Round 1 projects is expected to begin in 2018, leading to a forecast installed capacity of 2.5GW by the end of 2025. Announced sites are likely to be built, if not on the planned timescale.

The French Government is committed to local content in offshore wind farms. Wind farms have been leased to consortia led by French companies EDF and GDF. Supply chain development in France is being led by turbine manufacturers Alstom and Adwen. Both turbine manufacturers have signed agreements to develop manufacturing facilities in France. Companies looking to export to France will find the market difficult to penetrate without committing to inward investment or partnering with French suppliers.

In 2015, the French Government announced four 30MW demonstration sites for floating foundation technology. There are also reports of a Round 3 tender for commercial scale offshore wind in quarter three, 2017.

The French consenting process is more complex than in other European countries, with several permits required from different licensing bodies.

Rest of Europe

Other European markets with over 500MW of installed capacity deployed by the end of 2015 include Belgium and Denmark. European countries with less installed offshore wind capacity include Ireland, Finland, Sweden, Norway and Portugal. In total, the rest of Europe had an installed capacity of 2.2GW by the end of 2015 and is expected to reach 7.9GW by 2025.

China

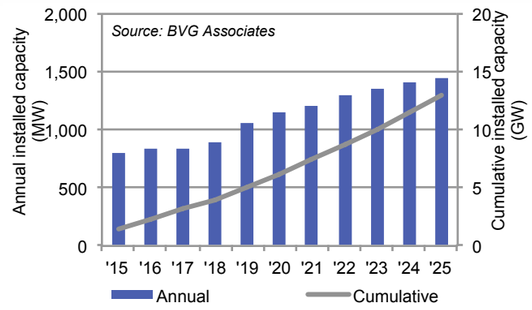


Figure 16

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

At the end of 2015, China had about 1.4GW of installed offshore wind capacity, mostly in shallow or intertidal waters. Significant new capacity is expected to come online in 2016 with nine projects currently under construction. By the end of 2025, installed capacity is expected to reach almost 13GW.

Typically, Chinese turbine manufacturers such as Sinovel, Goldwind and Shanghai Electric have supplied both near-shore and intertidal projects. Siemens has supplied around 50MW of capacity and is contracted to provide turbines for China's first large scale project in 2016. Other supply and install activities have usually been undertaken by local suppliers rather than using European companies. The current installation fleet is weak, with most projects using barges and sheerleg cranes. Deeper water projects will require investment in new vessels or charters from European contractors. UK enablers such as UKTI are actively working with their Chinese counterparts to introduce expert UK suppliers to this large market.

There is political support in China for offshore wind development. An offshore wind feed-in tariff was announced by the Chinese Government in 2014, which is set to be reviewed again in 2017. Competition between regions is high in China and regional governments have introduced additional feed-in tariffs to encourage developments.

Japan

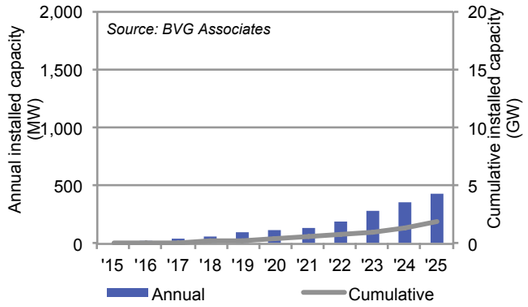


Figure 17

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

The offshore wind industry in Japan is at an early stage of development, with only 50MW of capacity installed at the end of 2015. The 2011 nuclear disaster at Fukushima led to a shift away from nuclear towards renewable energy. The focus has been on floating offshore wind as waters shallower than 50m depth are limited. Japan has launched three floating wind concepts including the world's first floating substation. However, Japan's New Energy and Industrial Technology Development Organisation (NEDO) recently announced that 270MW of fixed foundation capacity will be supported in Port of Noshiro, Akita Port and Ishikari Bay.

A large portion of activity has been supported by the government and has proved to be very expensive. There is less pressure for cost reduction due to the incentives available. Offshore wind generation in Japan is further supported by a feed in tariff.

Locations of early projects have been influenced by sea bed ownership disputes between fishermen and port authorities.

Technology development in Japan has been dominated by indigenous companies. Japanese project investors may value synergies with relevant investments they have made in Europe. For example, UK-based Seajacks is owned by Japanese investors and has set up Seajacks Japan.

Rest of Asia

TAIWAN has set an ambitious offshore wind target of 4GW installed by 2030. The Taiwanese government has identified 36 areas for development and the country's first offshore wind project is expected to be generating by 2018. This project has already contracted European suppliers such as Siemens and A2Sea. A floating offshore wind project is also planned using French company Ideol's "damping pool" technology.

SOUTH KOREA's first offshore wind farm, a 30MW project, was under construction as of the end of 2015. Further large offshore wind zones are at an early stage of development.

In September 2015, INDIA approved its National Offshore Wind Energy Policy, and has since untertaken preliminary assessments for offshore wind sites. However, deployment levels may be tempered by the country's continued, high levels of investment in fossil fuel generation capacity.

USA

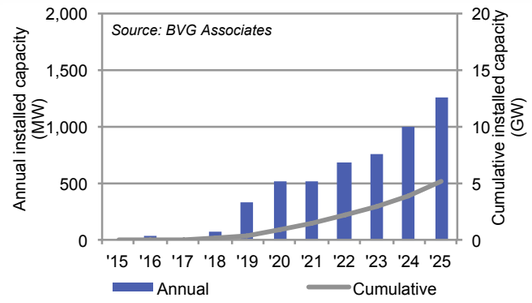


Figure 18

Criterion	Grade
Installed capacity by the end of 2025	
Openness of the market	
Political support for offshore wind	
Consenting and regulatory environment	

The first US offshore wind farm is under contruction at Block Island (Rhode Island) and it is due to be commissioned in 2016. Several large projects have secured lease agreements and have started conducting environmental surveys. By the end of 2025, it is expected that North America will have around 5GW of installed capacity.

As an emerging market, it is expected that the US will remain open and will utilise existing European supply companies where appropriate, reflecting the findings of a recent report from the National Renewable Energy Laboratory . The market has shown that it is an attractive option for experienced European developers. In 2015, DONG Energy was awarded the rights to the 1GW Bay State project in Massachusetts.

The US has a relatively narrow continental shelf and is well placed to develop a significant floating offshore wind market.

A barrier to the US market is The Jones Act, which stipulates that vessels operating out of US ports must be built, owned and crewed in the US. The US market alone is unlikely to support an investment in jack-up vessels needed for turbine installation in the short term. One potential solution is European operated installation vessels fed by feeder vessels that can transport components from a US port.

There is wide political support for developing a US market. Federal Government has suggested targets of 86GW by the end of 2050 .

Offshore wind sites are identified and leased by the Bureau of Ocean Energy Management. Consenting is undertaken at state level.

Strategies for market entry

Market differences

The offshore wind market is different to oil and gas in a number of areas. It is essential that oil and gas companies seeking to diversify into offshore wind understand these nuances and prepare accordingly. Table 19 compares and contrasts the differences between the sectors.

Areas	Offshore wind market characteristics	Oil and gas market characteristics
Volume and nature of supply	High numerical demand for standardised goods and services	Low numerical demand for bespoke goods and services
Subsidies	Direct price support	Indirect tax credit support
Culture	Innovation at pace in an environment with technical unknowns	Incremental innovation within an established environment
Value	Achieved through intellectual property ownership	Achieved through efficient control of spend and product standardisation
Contracting	Less established processes and adversarial in nature to stimulate cost reduction	Standardised contract header terms with high collaboration across supply chain

Table 19 – Summary of key market differences

Capabilities required in offshore wind

Prospective suppliers to the offshore wind sector must consider whether they have the correct capabilities across a number of areas:

- Manufacturers must be able to carry out serial production efficiently. Installation and operations contractors must be able to repeat high-risk operations over a large geographical area – an offshore wind farm may have 100 turbines and cover 100km2.
- Offshore wind needs to reduce cost therefore margins are tightly controlled throughout the supply chain. Suppliers must be able to standardise their offering across multiple wind farms in order to maintain profitability.
- Offshore wind developers are focused on innovating to reduce costs. This presents opportunities for oil and gas companies to transfer proven concepts and do things differently. In an industry used to embracing rapid change, flexibility is a valuable asset.

Challenges to entry

Oil and gas companies need to understand the challenges they may face when entering the offshore wind market, and seek to mitigate these where possible.

Lack of track-record
Gaining a credible track-record can be a challenge for new entrants to the offshore wind sector. The industry emerged in Europe 25 years ago, and in order to compete with more experienced players, oil and gas companies must focus on demonstrating technical, commercial and logistical experience in offshore operations applicable to wind. Partnerships with existing offshore wind suppliers can help establish credibility and are often an effective way to enter the sector.

Risk-averse investors
Early offshore wind farms were balance-sheet financed by big utilities. As projects get bigger and more complex, third party project finance will become more prevalent. This type of support may involve institutions that are relatively risk-averse meaning that displacing incumbent suppliers who have a proven track-record can be difficult. Oil and gas suppliers should aim to mitigate this by ensuring that goods and services offered to the offshore wind sector are approved and qualified to a recognised standard.

Cost competitiveness
Some customers in the offshore wind industry believe that oil and gas companies are expensive to use. It is important when tendering that oil and gas companies highlight their value proposition to offshore wind, making clear their costs and value-add capabilities. Oil and gas suppliers should aim to price competitively by demonstrating learning and standardisation improvements in tenders and seek to recover margins via higher volume economies of scale, where applicable.

Fixed price contracts
Offshore wind projects require suppliers to adhere to fixed budgets and delivery schedules. Oil and gas companies must demonstrate an ability to work consistently under such conditions. Offshore wind CAPEX contracts are typically lump sum fixed price contracts, where the level of supplier contingency is negotiated. Offshore wind developers often expect long warranty periods on capital and installation spend and OPEX contracts are often linked to asset uptime. Oil and gas contracts can include incentives to deliver early or under budget, but this practice is not yet fully established within offshore wind.

Summary

The offshore wind sector presents oil and gas suppliers with an exciting new opportunity and access to a growing business stream. By serving both markets, oil and gas suppliers can spread their risk profile and mitigate some of the uncertainties within the oil and gas sector. As Figure 19 shows, the value of high potential areas of opportunity for oil & gas (coloured green), is significant and is set to grow with time.

Key reccomendations for oil and gas companies seeking to diversify into offshore wind are:

- **New entrants from the oil and gas sector with a focus on supplying capital items should target multiple projects and seek out framework opportunities.** Offshore wind is capital intensive and capital spending is concentrated within a short period of the project lifecycle.

- **Operational spend on offshore wind farms offers suppliers certainty of long-term demand and customers are keen to use local companies to create a sustainable supply chain.** Oil and gas suppliers have a fantastic track-record of servicing assets in harsh offshore environments and as a consequence there are an abundance of diversification opportunities.

- **Oil and gas suppliers need to offer prospective customers cost competitive or innovative solutions to displace the existing supply chain.** Offshore wind faces the challenge of deploying larger and more reliable assets further from shore whilst reducing costs. A strong and competent supply chain has grown to support the offshore wind industry. In areas such as project management, installation and OMS, however, the synergies between offshore wind and oil and gas are high and offshore wind can benefit from the best practice and skills from within the oil and gas sector.

- **Emerging offshore wind technologies such as floating turbines will offer opportunities for oil and gas suppliers based on the high synergy of offshore structures within both sectors.** Many aspects of offshore wind supply are still in the embryonic stage and there is an opportunity for progressive oil and gas suppliers to help shape offshore wind practices that can contribute towards the delivery of cost reduction across the next decade.

- **Oil and gas suppliers must be aware of the differences within the sector and plan a market entry strategy accordingly.** Oil and gas suppliers must demonstrate to offshore wind customers that they can bring significant value-add to the sector and they must convey a message of long-term commitment and support of the sector.

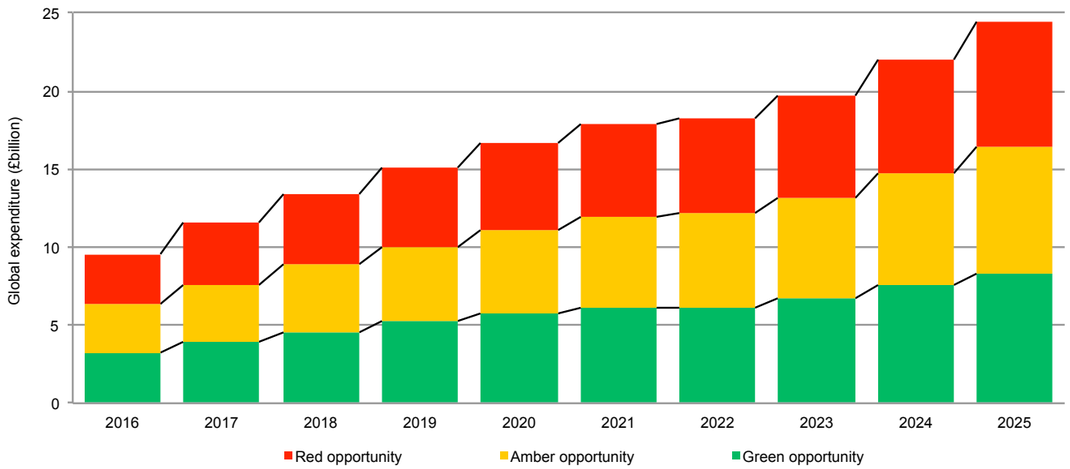


Figure 19 – Annual global expenditure in offshore wind to 2025 graded by oil and gas attractiveness

Support for Scottish Companies

There are a number of initiatives and organisations that can support oil and gas companies to identify, develop and exploit opportunities within offshore wind. This guide sets out existing support available for Scottish companies in the areas of supply chain, innovation, finance, and business development. The guide contains only a high level summary of particular schemes that is correct at the time of writing. Further information on each scheme is available from the provided links.

Offshore Wind Scotland

The Offshore Wind Scotland website has been designed as a 'one-stop shop' for anyone interested in the burgeoning offshore wind industry in Scotland. It contains key information about the sector including support, publications, company case studies, and news & events.

http://www.offshorewindscotland.org.uk/support

Offshore Renewables Supply Chain Directory

The Offshore Renewables Supply Chain Directory lists hundreds of Scottish companies with the capability to supply the offshore renewables sector. It enables developers and Tier One companies to search for specific industry expertise and provides an excellent opportunity for companies to register and showcase their potential to supply this rapidly growing sector.

http://www.scottish-enterprise.com/offshoredirectory

Offshore Wind Expert Support

Offshore Wind Expert Support helps Scottish companies that have not traditionally been involved in the offshore wind sector to consider and build diversification strategies. The programme provides up to two days of free one-to-one support from specialist advisors with knowledge and experience of the offshore wind sector. The advisors can help companies with a range of advice, including:

- Market entry requirements
- Market/supply chain positioning
- Reviewing existing company capabilities (e.g. skills, processes) and their potential for application in the offshore wind industry
- Suitability of a specific product or service to the sector

The aim of the support is to identify and explore appropriate revenue streams for companies seeking to enter the offshore wind sector. The support culminates in the production of a company specific action plan with key milestones to help companies take forward their offshore wind ambitions.

In addition, follow-on four days of 50% funded support can be provided where technical due diligence is deemed appropriate.

http://www.scottish-enterprise.com/offshoreopportunities

Energy Skills Scotland

Led by Skills Development Scotland (SDS), the Energy Skills Scotland inititive brings together employers and education to meet the skills demands of the energy sector. The inititive supports employers to engage with education providers to make sure the skills being taught are those needed by the industry, and helps employees by providing greater access to skills development and training in the energy sector.

http://www.energyskillsscotland.co.uk

SDI

Scottish Development International (SDI), the international arm of Scottish Enterprise, is here to help Scottish companies find new business in markets around the world. SDI offers a variety of services in areas such as researching potential export markets, finding the best routes to market, overcoming challenges to accessing finance and setting up overseas. By utilising the skills and expertise of the SDI team, companies will gain insight and expertise to help them trade successfully overseas.

http://www.sdi.co.uk

SMAS

The Scottish Manufacturing Advisory Service (SMAS) provides expert advice, one-to-one support, training and events for manufacturing businesses of all sizes in Scotland. The SMAS team is made up of hands-on experts in process improvement, lean manufacturing, innovation and allied disciplines. They help companies to identify and address their manufacturing challenges and opportunities, and work with them to deliver tailored manufacturing improvement support.

http://www.scottish-enterprise.com/industry-support/manufacturing

RSA

Regional Selective Assistance (RSA) can provide funding for investment projects that will create or safeguard jobs in Scotland. RSA is available to limited companies, sole traders or partnerships, based in Scotland or with an intention to locate in Scotland. To qualify, your project must:

- Take place in Scotland within an 'assisted area'
- Directly create or safeguard jobs within your business
- Not be offset by job losses elsewhere
- Involve an element of capital investment
- Be mainly funded from the private sector

http://www.scottish-enterprise.com/services/attract-investment/regional-selective-assistance/overview

SMART: Scotland

SMART: Scotland is a discretionary grant that supports Scottish-based SMEs to undertake technical feasibility studies and research and development projects with a commercial endpoint. The fund aims to mitigate the technical risks and challenges associated with defining and developing new technologies.

http://www.scottish-enterprise.com/services/develop-new-products-and-services/smart-scotland/overview

R&D Grant

The Scottish Enterprise R&D Grant is a discretionary grant that supports Scotland based companies to develop new products, processes and services. The fund aims to support projects with good commercial prospects that represent a significant innovation for the company concerned.

http://www.scottish-enterprise.com/services/develop-new-products-and-services/rd-grant/overview

Seek and Solve

Scottish Enterprise's Seek and Solve R&D grant helps Scottish companies, particularly SMEs, to take advantage of innovation demand from larger companies, regardless of where the larger company is located. A typical Seek & Solve project will last between 6 and 36 months, with Scottish Enterprise funding up to 45% of eligible project costs. Projects must represent a significant innovation for the company concerned and significant risks should be associated with the challenge of developing a new product, process or service.

http://www.scottish-enterprise.com/services/develop-new-products-and-services/seek-and-solve/overview

Appendices

Appendix A: Procurement Strategies

Offshore wind developers generally adopt either a multi-contracting strategy or an engineer, procure, construct, install (EPCI) strategy.

Under a multi-contracting strategy, the developer typically awards around nine main contracts covering the key elements of the wind farm, shown in Figure 20. Some packages can be split or combined depending on a developer's needs, preferences or capabilities.

Multi-contracting is often preferred by large utilities, particularly if the project is funded from their balance sheet. DONG, E.ON, Scottish Power, Statoil and Vattenfall typically favour this approach.

The ownership and construction of the grid connection (substation and export cables) varies between countries. In the UK, assets have generally been built by the developer and then sold on to a third party.

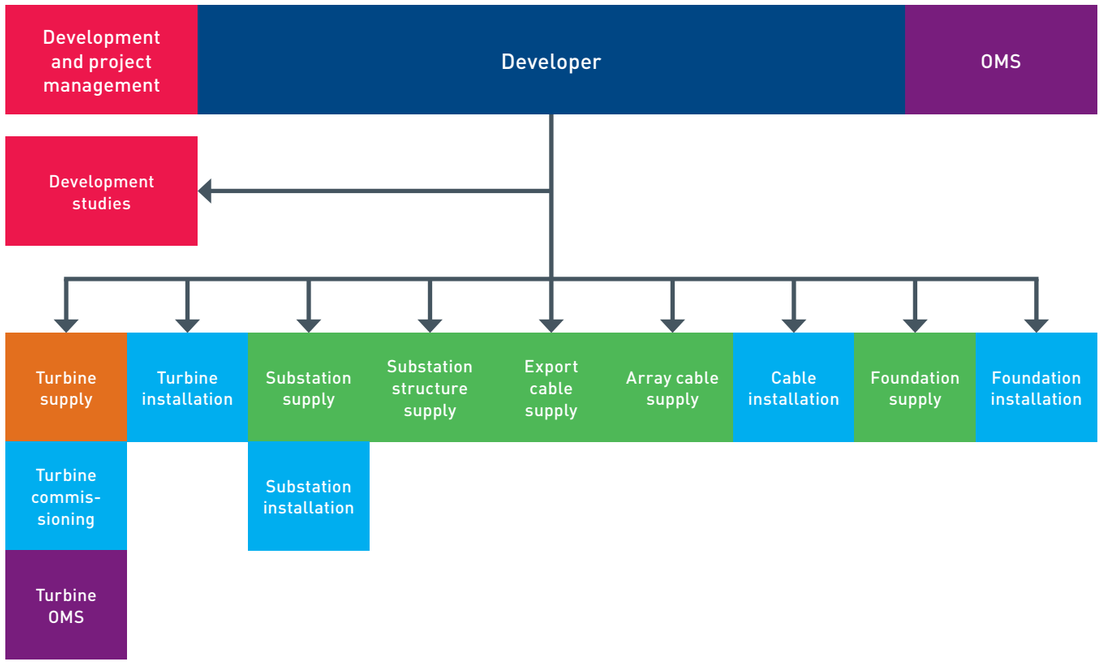


Figure 20 – Typical multi-contracting structure for offshore wind

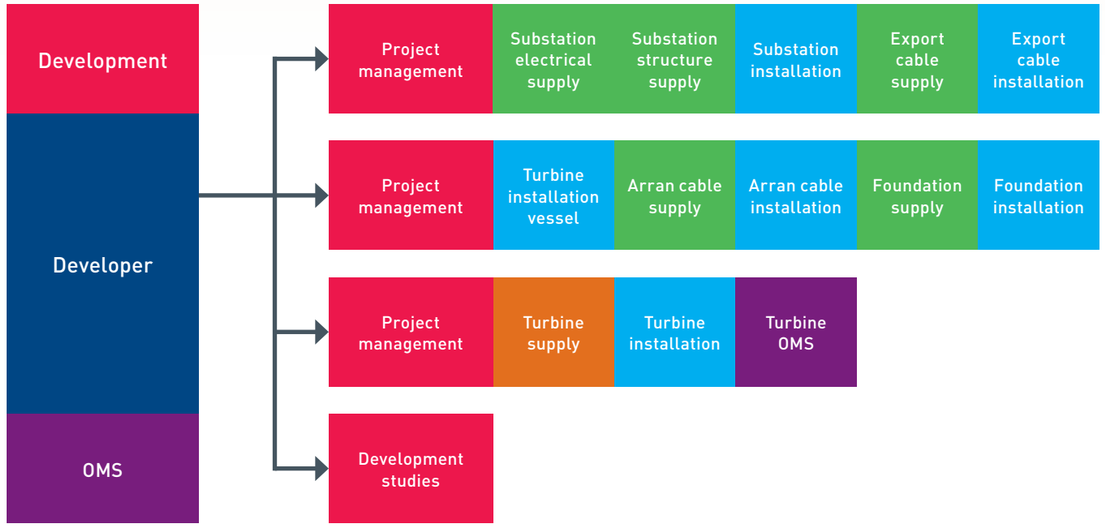


Figure 21 – Typical EPCI structure for offshore wind

EPCI contracting usually involves three main packages as shown in Figure 5. The turbine package is typically kept separate as this is a critical one for the wind farm design and therefore needs to be specified before the remaining contracts can be finalised. The other two packages vary in scope according to the strengths of the bidders. Contract values can exceed £1 billion, which is a major risk for all but the largest and most experienced contractors. The interfaces between the non-turbine packages are not difficult for the developer to manage.

Independent developers and less experienced utilities prefer this approach. EPCI has been less common than multi-contracting in the UK but has been preferred by SSE and is the approach used by the developers of the Neart na Gaoithe wind farm (Mainstream) and other projects in development in Scotland, namely Moray Firth (EDPR) and Inch Cape (SDIC Power)

Appendix B: Innovation and cost reduction

Innovation and cost reduction have always been at the heart of the wind industry. As a result, onshore wind is now widely considered to be the cheapest source of renewable energy and in some regions the cheapest source of new electricity generation. The turbine manufacturers and developers of offshore wind farms are, in many cases, the same companies that are operators of onshore wind farms therefore the same focus on reducing reliance on subsidies pervades both sectors.

Technical innovations are expected across the supply chain and analysis shows that a levelised cost of energy of £85/MWh by the mid 2020s is attainable. Figure 6 shows the expected areas of cost reduction. Details of how this can be achieved are summarised in Appendix A. The offshore wind industry has made significant progress in the last five years. The benchmark for offshore wind costs is new combined cycle gas turbine (CCGT) generation. Although comparisons are difficult, there is confidence that by the mid-2020s some new offshore wind farms will produce cheaper electricity over their lifetimes than CCGT power stations (see Box 1).

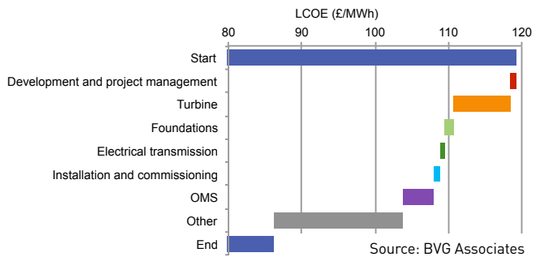


Figure 22 – Impact of innovations in each area of the supply chain

Box 1 Levelised cost of energy

The levelised cost of energy (LCOE) is considered the fairest measure by which different generating technologies are compared. It is made up of amortised CAPEX and average OPEX costs, with constant annual energy assumed over the lifetime of a plant.

Figure 23 shows the forecast LCOE for offshore wind and CCGT. From an LCOE base of £120MW/h in 2015, offshore wind costs are expected to drop below the £100MW/h level by 2018 and reach £85MW/h by 2025 representing a 28% improvement in a decade.

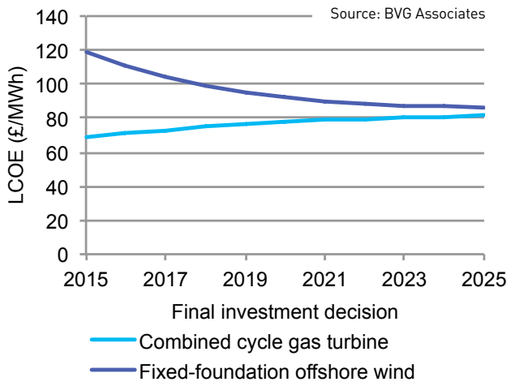


Figure 23 – Forecast levelised cost of energy for new generating capacity for offshore wind and combined cycle gas turbine generation to 2025. All prices are in 2015 values

This analysis assumes:

- The weighted average cost of capital (WACC) is 10% for CCGT and falls for offshore wind from 10% to 7% as the technology improves.
- Lifetime of the plant is 20 years.
- There are three years between FID and operational plant for offshore wind and four years between FID and operational plant for CCGT.
- Turbine size changes from 6-8MW for final investment decision in 2015 to 8-10MW for FID in 2025.
- The average size of offshore wind projects increases from 400MW in 2015 to 800MW in 2025 and they will be further from shore.
- The capacity factor for offshore wind (actual generation divided by theoretical maximum) is expected to increase from 37% to about 47%, and
- The gas and carbon prices follow DECC's reference scenario.

Appendix C: Main areas of cost reduction and their expected saving in the levelised cost of energy.

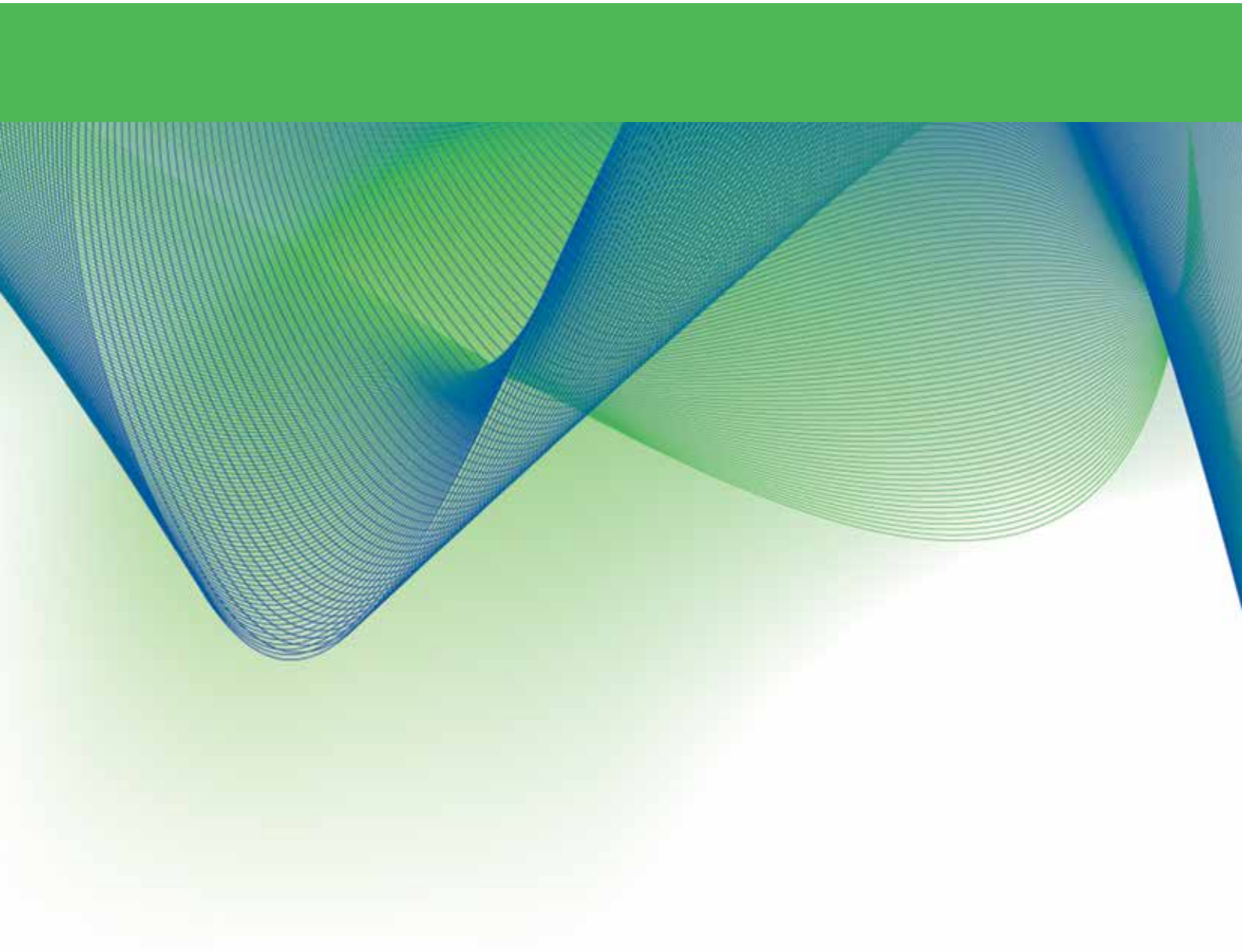
Supply chain element	Expected LCOE saving	Main impacts
Development and project management	0.7%	• New design tools to optimise wind farm design • Floating LiDAR systems to provide greater confidence in production forecasts
Turbines	6.5%	• Larger turbines will increase turbine cost/MW but will drive an increase in energy production and a reduction in balance of plant and OMS costs • More reliable turbines reduce OPEX and increase Annual Energy Production (AEP)
Foundations	1.0%	• Developments in jacket structure design and manufacture will reduce fabrication and installation costs • Suction bucket foundations will reduce installation costs • Gravity-base foundations will reduce installation costs
Electrical transmission (substations and cables)	0.5%	• Higher voltage array cables will reduce the length of cable needed where optimised array cable design will lower overall cable cost • Modular substation designs will reduce fabrication, installation and maintenance costs
Installation and commissioning	0.8%	• Larger installation vessels for foundation installation will shorten the construction programme • Less sensitivity to weather will lead to less vessel downtime and shortened construction programmes
Operation, maintenance and service	3.5%	• Developments in maintenance strategies to minimise OPEX and reduce turbine downtime • Condition-based maintenance will enable better planning of intervention and less turbine downtime • Better access systems will lead to less turbine downtime
Other	14.7%	• Lower cost of finance with innovative approaches and a better understanding of offshore wind risk

Appendix D: Oil and gas to offshore wind synergies

Major cost element	Sub-element areas of supply	
Development and project management	D1	Environmental surveys
	D2	Development services
	D3	Site investigations
	D4	Project management
Turbines	T1	Turbine assembly
	T2	Blades
	T3	Drive train
	T4	Power conversion
	T5	Large fabrications
	T6	Towers
	T7	Small components
Balance of plant	B1	Array cables
	B2	Export cables
	B3	Transmission
	B4	Substations structures
	B5	Turbine foundations
	B6	Secondary steelwork
Installation and commissioning	I1	Installation ports and logistics
	I2	Turbine & foundation installation
	I3	Cable installation
	I4	Substation installation
	I5	Installation equipment
	I6	Installation support services
	I7	Onshore works
Operation, maintenance and service	O1	Fuel and consumables
	O2	Maintenance and inspection services
	O3	Offshore logistics
	O4	Vessels and equipment
	O5	O&M ports
	O6	Communication systems
	O7	Inventory management
Decommissioning	M1	Ports and logistics
	M2	Marine operations
	M3	Salvage and recycling
	M4	Project management

Appendix E: Oil & gas to offshore wind synergies

Scottish Enterprise



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