

Offshore Supply Industry Dynamics

The Main Drivers in the Energy Sector and the Value Chain Characteristics for Offshore Oil and Gas and Offshore Wind I

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THOMAS ROSLYNG OLESEN

OFFSHORE SUPPLY INDUSTRY DYNAMICS

The Main Drivers in the Energy Sector and the Value Chain
Characteristics for Offshore Oil and Gas and Offshore Wind



CBS MARITIME

CROSS-DISCIPLINARY AND PROBLEM-FOCUSED RESEARCH
AND EDUCATION IN THE MARITIME INDUSTRY CONTEXT

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This short report forms part of the ambitious CBS Maritime research initiative entitled “Competitive Challenges and Strategic Development Potential in Global Maritime Industries”, which was launched in 2014 with the generous support of the Danish Maritime Fund. The competitiveness initiative targets specific maritime industries (including shipping, offshore energy, ports, and maritime service and equipment suppliers) as well as addresses topics that cut across maritime industries (regulation and competitiveness). The topics and narrower research questions addressed in the initiative were developed in close dialogue between CBS Maritime and the maritime industries in Denmark.

CBS Maritime is a Business in Society (BiS) Platform at Copenhagen Business School committed to the big question of how to achieve economic and social progress in the maritime industries. CBS Maritime aims to strengthen a maritime focus at CBS and create the foundation for CBS as a stronger partner for the maritime industries, as well as for other universities and business schools with a devotion to maritime economics research.

The competitiveness initiative comprises a number of PhD projects and five short-term mapping projects, the latter aiming at developing key concepts and building up a basic industry knowledge-base for further development of CBS Maritime research and teaching.

This present report “Offshore Supply Chain Dynamics – The main drivers in the energy sector and the value chain characteristics for offshore oil and gas and offshore wind”, contains an analysis of the main drivers in the energy sector (macro level) and explains the value chain characteristics for offshore oil and gas and offshore wind (meso level).



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PURPOSE AND METHODOLOGY

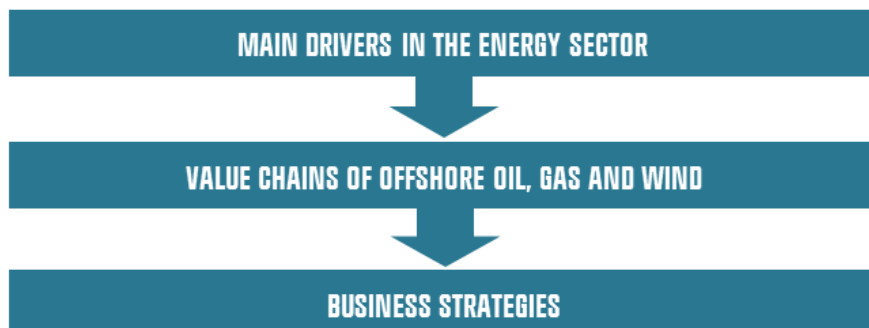
The offshore supply industry is often being treated as a part of the general marine supply industry. In January 2014 Balance Technology Consulting produced the report *Competitive position and future Opportunities of the European Marine Suppliers Industry* (Balance Technology Consulting, 2014). The report offers valuable insights into an extremely complex industry including shipbuilding, ship repair, retrofitting, boat building and offshore suppliers. The complexity of the industry, however, also means that all aspects of maritime systems cannot be covered equally detailed: “Especially those for offshore operation (production, processing, drilling, exploration etc.) may not be sufficiently mapped” (Balance Technology Consulting, 2014, p. 19).

Most offshore suppliers are indeed a part of the marine supply industry. But the value chains for offshore oil, gas and wind also differ from the value chains for shipbuilding and ship repair in several ways: (1) The offshore value chains include a number of extremely specialized suppliers which are not part of other maritime value chains. (2) The offshore value chains are driven by the demand for energy and not by the demand for tonnage. And (3) the shipyards and shipping companies which are the end customers in the value chains for shipbuilding and ship repair are furthermore situated as suppliers or even sub suppliers in the value chains for offshore oil, gas and wind. For these reasons it seems reasonable that the two offshore sectors deserve a more thorough mapping.

This report aims at filling this gap by examining four main questions.

1. What factors shape demand and supply in the value chain for offshore oil and gas and offshore wind, and how do they influence investments?
2. What activities characterize the value chain for offshore oil and gas and the value chain for offshore wind?
3. What types of suppliers are present in the value chain for offshore oil and gas and offshore wind, and how can they position themselves within the value chains?
4. What factors determine if suppliers can move from one value chain to the other?

In order to answer these questions this report applies a process model approach. Process modelling is basically used to analyze the processes within a business or industry. It uses a top down approach with several levels from the overall processes to detailed activity descriptions. Each new level thus offers a higher degree of details (Lyridis et al. 2005; Lagoudis et al. 2004).



At the top level the report examines the factors which affect the global demand for energy, which is the main driver in both value chains. Global economic growth, the technological development, regional characteristics, the price and

availability of energy various energy sources all influence the demand for energy. In this regard the states are important actors which influence the supply and demand for energy through policy making. This may include energy security issues, environmental concerns, geo political influence etc. Several factors thus influence investments in one sector or the other.

Moving to the industry level the report applies a typical Porter value chain approach to give a detailed overview of the upstream offshore oil and gas industry and the offshore wind industry (Porter, 1985). A value chain maps the full range of activities which are required to bring a product or service from conception, through the different phases of production. Each link includes an even more detailed number of activities and actors each of which may feed into a number of different value chains. Apart from providing a detailed overview of the flow of goods and services within the chain (and between different chains) the value chain approach also helps to explain the global distribution of activities within the global economy (Kaplinsky & Morris, 2003).

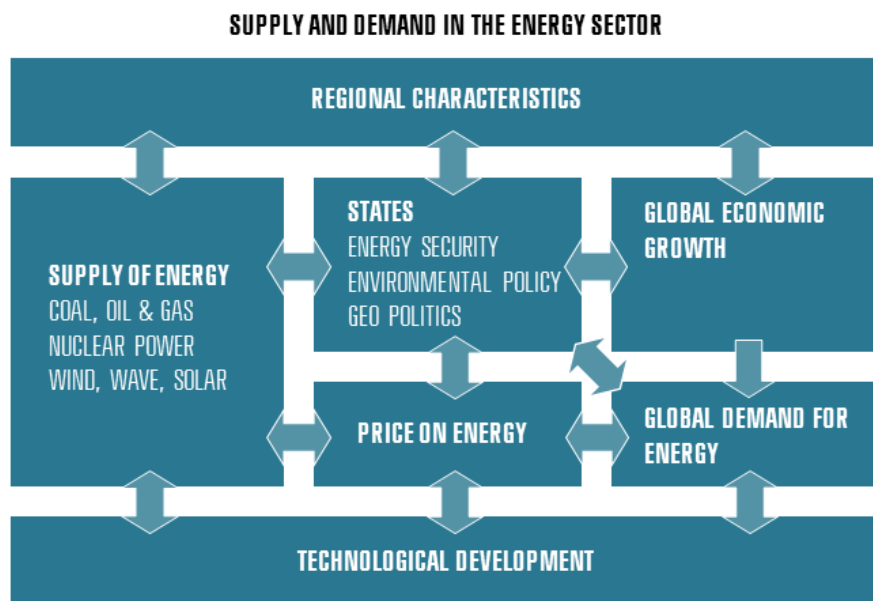
The report is divided into 6 main sections. After the introduction (page 5) and the purpose and methodology section (pages 6 to 7) the main drivers in the energy sector are identified on pages 8 to 10. On page 8, the factors influencing the global demand for energy are examined, while the factors influencing the global supply of energy are examined on pages 9 to 10. It is explained how the macroeconomic factors shape the basic structure of the two offshore value chains on page 11, and pages 12 to 24 map the value chain for offshore oil and gas. This section is divided into five links or phases: Tender & concession (page 12), exploration (pages 13 to 15), installation (pages 16 to 19), production (pages 20 to 23) and field abandoning (pages 23 to 24). On pages 25 to 33, the value chain for offshore wind through the same five links are mapped, while pages 34 to 35 examine how the offshore suppliers can position themselves in the two value chains. Finally, which factors can determine if a supplier can move from one value chain to the other is examined on pages 36 to 38. The report is concluded with a brief summary on pages 39 to 40.



Foto: Scanpix/iris

THE MAIN DRIVERS IN THE ENERGY SECTOR

The value chain for offshore oil and gas and the value chain for offshore wind are both part of the global market for energy. The following sections present a macro level analysis of the main factors and key actors which influence investments in the two value chains.



GLOBAL DEMAND FOR ENERGY

The value chains for offshore oil and gas and offshore wind are both driven by the global supply and demand for energy. At the macro level the demand for energy is mainly determined by (1) the global economic growth, (2) the technological development, (3) the price on various energy sources, and (4) the energy policy of the states (energy security, geo politics and environmental policy). The factors are interrelated (the energy policy of the states will thus determine the supply, demand and price for various energy sources, their economic policy may influence economic growth etc.) and characterized by regional differences (different patterns of supply and demand for energy in countries like Saudi Arabia and the Faroe Islands, different level of growth in Asia and Africa etc.).

High global economic growth generally leads to high demand for energy and vice versa. The technological development determines the intensity of the energy consumption (more efficient engines or power plants may lower demand for energy). Demand for energy is furthermore influenced by the price (and availability) of different energy sources. There are a number of different energy sources available at various prices. Renewables like wind energy, wave energy, solar energy and hydro energy produce electricity (which can be turned into heating) while fossil fuels (coal, oil and gas), nuclear energy and geothermal energy produce heat (which can be turned into electricity).

The different sources of energy are, however, not perfect substitutes. In the short run the energy infrastructure determines what types of energy sources can be used for energy production. Countries with a centralized energy infrastructure usually produce energy from centralized plants (coal, nuclear etc.) while countries with a decentralized energy

infrastructure usually depends on local diesel power plants. A switch from e.g. coal to wind energy or nuclear energy demands the appropriate investments in new energy infrastructure (a windmill park or a nuclear power plant) and time to establish the new facilities. Furthermore, some countries are restricted from some types of energy sources (you need the adequate rivers in order to install a hydro plant etc.)(Peirce 1996).

In the long run, however, the various sources of energy are technical substitutes – provided that the final consumer requires either heat or electrical power. A shift from one energy source to the other, however, requires extensive investments in (new) energy infrastructure (e.g., new plants, windfarms and cables) but also changes in energy policy, businesses, institutions etc. In reality it is thus a very long and difficult process for any country to switch from one source of energy to the other e.g. from a system dependent on fossil fuels to an energy system which is 100% dependent on sustainable energy (Peirce 1996; Smith et al., 2010; Solomon et al., 2011).

Even if the sources for producing heating and electricity are technically useful substitutes in the long run, there are two other areas where substitution has proven difficult: (1) In industrial processes with highly specific input requirements (e.g., natural gas in fertilizer manufacturing) and (2) liquid fuels for transportation. The liquid fuels have special advantages for transportation because they are easy to handle. They have a high energy ratio to weight and thus need a small amount of space for storage. Liquid fuels can be substituted in transportation: Cars can be powered by electricity or propane gas and ships can be powered by nuclear power, natural gas, wind or coal and to some extent also by electricity. For most types of transportation the demand for liquid fuels is thus fairly in-elastic as it will be purchased even when they are more expensive than alternative sources. In this regard, the energy infrastructure (e.g., rechargers for electric cars) and the level of technological development (e.g., increased operational range of electrical cars, airplanes propelled by electricity) are important factors in increasing substitution in the transport sector (Peirce 1996; Smith et al., 2010; Solomon et al., 2011).

There are thus several conditions to be fulfilled when substituting from one source of energy to the other, and despite the various sources of energy the global energy production is still extremely dependent on fossil fuels. In 2011 fossil fuels (oil, gas and coal) accounted for 82% of the global consumption, followed by renewables (13%) and nuclear power (5%) (World Energy Council, 2013).

The final factor influencing the demand for energy is the policy making of the states. All states are energy consumers and the demand for (and availability of) various sources of energy is heavily influenced by national and international energy policies. On the demand side, energy policy usually includes (1) energy security and (2) environmental policy. Energy security is to have access to the necessary sources of energy. This is a major concern for most states, which depend on import of energy sources. This was seen in 2006 and 2009 when Russia cut off the gas supply to Ukraine and thereby also disrupted the supply to several European countries (Pirani et al., 2009; Stern, 2006; Kovacevic, 2009). Substitution from imported fossil fuels to renewables can be an effective way for a state to become an energy producer and thus reduce dependence on imported energy sources. As already mentioned there are, however, certain barriers to overcome when implementing this type of changes. Increased environmental concerns about global warming and local air quality are also affecting public energy investments in many countries. Environmental policy has led several states to invest in renewable energy sources and reduce the dependence on fossil fuels. For the major producers of fossil fuels environmental policy is generally of lesser concern.

GLOBAL SUPPLY OF ENERGY

The supply side of the global energy market is also influenced by a number of factors. These include (1) the geographical distribution of various sources of energy, (2) policymaking of the energy producing states, (3) the technological development, and (4) the price of various sources of energy. All factors are interrelated and characterized by extensive regional differences.

The supply of energy is heavily influenced by the fact that the world's energy resources are not evenly distributed. The deposits of fossil fuels – which accounts for app. 82% of the global energy consumption – are restricted to certain geographical areas. Close to 60% of the proven reserves of fossil fuels are thus situated in five countries (Saudi Arabia, Iran, Iraq, Kuwait and United Arab Emirates). This means that some states control the supply of hydrocarbons while

others are dependent on imports. In contrast, most sustainable energy sources – e.g. wind and solar energy – are less dependent on specific locations. Renewables, however, only account for app. 13% of the global energy consumption, so the distribution of hydrocarbons is a vital factor on the supply side (World Energy Council, 2013).

The most important actors on the supply side are the energy producing states – mainly the ones controlling the major sources of hydrocarbons. This was clear during the oil crisis in the 1970s and was again being proved by Saudi Arabia in late 2014. These states will either act alone or through the intergovernmental organization OPEC. The major producers of fossil fuels will often use their oligopoly (and in some regions monopoly) status to obtain geopolitical influence. Many of these countries are, however, also highly dependent on their export of fossil fuels as a source of income. The low oil price in 2014-2015 thus resulted in severe economic problems for oil and gas exporting countries like Russia and Venezuela (Bowler, 2015).

The supply of various energy sources is heavily influenced by the technological development. New technologies have thus given access to new sources of energy and made exploitation of known resources feasible. The shale gas findings in the United States are an important example of this development which can lead to huge changes in the global energy markets. There are thus more proven fossil energy resources in the world than ever before (World Energy Council, 2013) and the regional distribution has changed. This can in many cases be attributed to the technological development. The technological development has also opened up for new (potentially unlimited) sources of renewable energy, and future inventions might further revolutionize the energy sector. Technological developments furthermore influences the cost of producing (and transporting) different types of energy (e.g., the price of extracting hydrocarbons, or the price of wind generated electricity) which again influences the supply of these energy sources.

Finally, the supply of different energy sources is influenced by the price. The major energy producers will usually try to adjust the supply to the demand in order to keep prices steady. In some cases, however, geopolitics or fight for market shares can lead to a mismatch between supply and demand, which can result in periods of very high or low prices of energy sources. This was seen during the oil crisis in the 1970s and again in 2014-2015. A mismatch in the demand and supply can also lead to changes in the supply of various energy sources. A prolonged period of high prices on certain energy sources (e.g., hydrocarbons) can thus lead consumers to investment in alternative energy production (e.g., windmills) and thereby increasing the supply of other energy sources (renewable energy) (Henriques & Sadorsky, 2007; Yergin, 2006).

The value chain for offshore oil and gas and the value chain for offshore wind are both heavily dependent on the changes in the supply and demand for energy. As shown above the states play an important role in this regard as an investor, through regulations and through energy policy etc. This heavily affects the overall structure of the two value chains.

THE BASIC STRUCTURE OF THE TWO VALUE CHAINS

The value chain for offshore oil and gas and the value chain for offshore wind are basically built up around the same structures. As explained in section 2 the main driver in both value chains is the demand for energy.

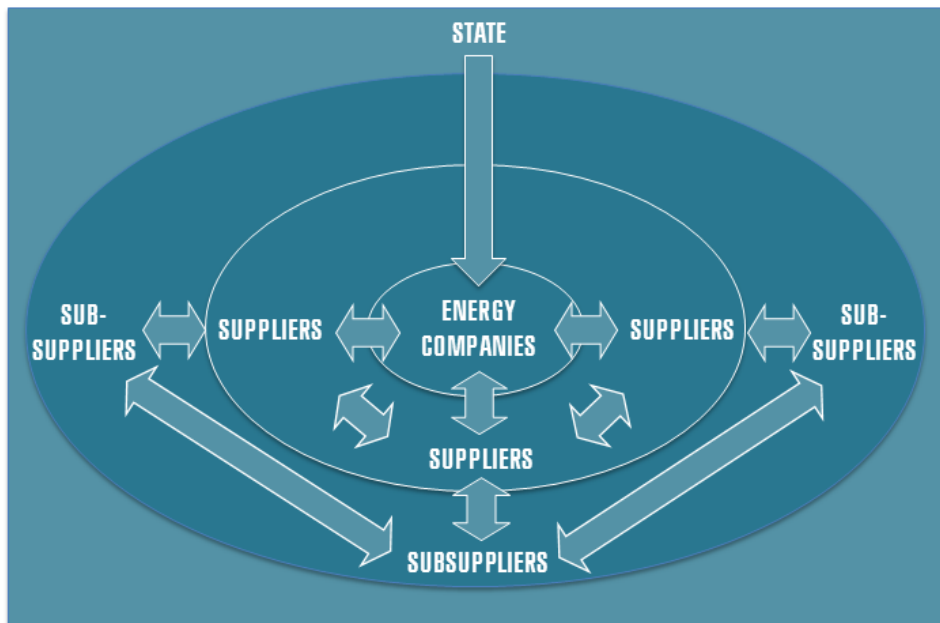
At the center of both value chains are the energy companies. The energy companies are very different in nature. Some are important producers of fossil fuels while others mainly produce and distribute energy. The importance of the energy sector means that many energy companies are national ventures partly or entirely controlled by the state. This is especially the case with the oil and gas producing energy companies (Bremmer, 2010).

The energy companies have a number of suppliers and sub-suppliers, which provide a range of products and services to the offshore operations. The supply industry is characterized by horizontal cooperation (between suppliers at the same level) and vertical cooperation (between suppliers in different layers) (Balance Technology Consulting, 2014).

Suppliers, sub-suppliers and the energy companies are supported by a number of companies, which are usually not considered as part of the offshore sector. These companies provide a number of services including legal advice, financing, insurance, etc.

Finally, all actors – energy companies, suppliers and sub-suppliers – operate within legal frames set up by the states. This includes legislation on pollution, labor market conditions, and concession rights etc. which embrace and influence both value chains.

MAIN ACTORS IN THE ENERGY SECTOR

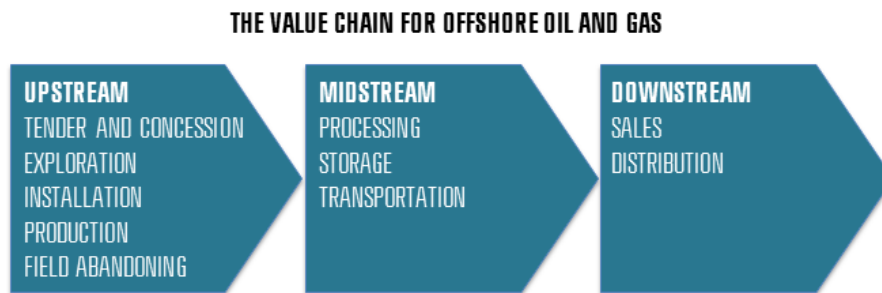


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THE VALUE CHAIN FOR OFFSHORE OIL AND GAS

The value chain for oil and gas basically follows the fossil fuels' way from discovery and extraction to processing, distribution and consumption. The value chain can be divided into three main parts: Upstream, midstream and downstream activities – each of which requires different competences.

The upstream activities include exploration and production of the fossil fuels from the underground. The main actors are the energy companies – often referred to as E&P's (Exploration and Production companies) supported by a wide range of suppliers and sub suppliers. The upstream activities need high investments and a high level of technology. The equipment used for exploration and production is thus extremely expensive and the E&P's are furthermore dependent on specialized knowhow from geologists who chose the exploration and engineers, which construct the necessary rigs and drill ships. The oil and gas exploration is furthermore characterized by a large degree of uncertainty as only few explorations can be used commercially. A decision to establish production requires a new wave of large investments in field installation before the production can be commenced.



The midstream activities include transportation of the oil or gas in tankers and/or pipes to the refineries where the product is being processed while the downstream activities include the distribution and sale of the processed product (Poulsen & Hahn-Petersen, 2011). This report focuses exclusively on the upstream activities.

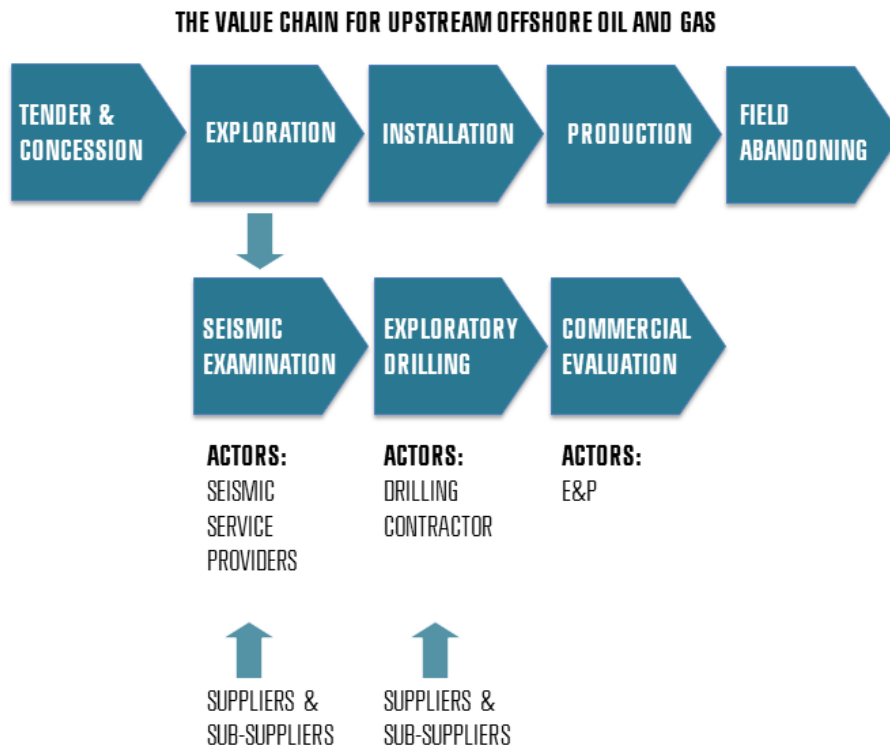
TENDER AND CONCESSION

The world's oil and gas resources are owned and controlled by the states. In order to extract the resources from the underground the state authorities grant concession rights to E&P (Exploration & Production) companies. The legislation and procedures involved in obtaining concession rights vary from country to country. In general, however, the states pursue three different strategies: (1) under the concessionary system the state grants exploration and development rights to a number of E&P's (public or private) which can afterwards produce the hydrocarbons they find. The state can also nationalize the oil production. This is either done by (2) having a state controlled national oil company produce the oil (e.g. Saudi Aramco in Saudi Arabia), or (3), through a so called product sharing agreement, where by a private company is paid to explore and produce the oil on behalf of the state. The latter is usually seen in developing countries, e.g., Tanzania's natural gas agreement with Statoil and ExxonMobil (World Energy Council, 2013; Henriques and Sadorsky, 2007; Yergin, 2006; Kabwe, 2014).

The value chain usually begins when the E&P's acquire the rights to explore and later commence production in a certain geographical area. Generally there are two ways for the E&Ps to obtain rights to commence exploration and production: (1) Tenders or (2) open door applications. In the first case the state will initiate a licensing round where E&P's can apply for rights to explore a certain area. When selecting among the applicants the state usually emphasizes the applicants' knowhow and economic background, the extent of exploration the applicant offers to perform and the benefits for society (the state). The E&Ps can also apply for the right to exploration and production in unlicensed areas – the so called open door procedure. The length of the exploration rights varies but can last up to 10 years (Energistyrelsen, 2012 & 2014). The main actors in the tender and concession phase are thus the states (license giver) and the E&P's (licensee) backed by the support sector (insurance, financing, legal advice etc.).

EXPLORATION

The exploratory phase usually consists of three main activities: (1) Seismic surveys and analysis, (2) exploratory drilling, and (3) commercial evaluation.



Seismic surveys and analysis

The first step in the exploratory phase is often to conduct seismic surveys in order to map the underground and identify potential sources of hydrocarbons. In some cases the seismic surveys are commenced by private seismic service providers before the concession rights actually are given in order to sell the data to the E&P's (Energistyrelsen, 2014). Seismic surveys use surface induced seismic pulses which are reflected from the subsurface and picked up by sensors on the surface. To create the seismic pulse the vessel can use a combination of air guns, water guns and other acoustic sources, which emit a variety of frequencies and thus provide a more accurate read of the subsurface terrain. The returning pulses are picked up by geophones attached to streamers, which are being towed after the ship. The information gathered by the geophones can then be translated into digital maps of the subsurface, which geologists and geophysicists can analyze to determine the presence of hydrocarbons. Based on the analysis, the E&P decides whether to move to the next step and conduct exploratory drillings or leave the area. The analysis of the subsurface data is thus extremely important as the

exploratory drillings are extremely costly. From 2006-2010 the average dayrate for a jack-up rig in the North Sea was 180.657 /day a floater in the same area amounted to 337.589 \$/day (Kaiser & Snyder, 2013; Rigzone, 2015).

As already mentioned, the surveys and analyses can be performed in-house by the E&P or be outsourced to one or more direct suppliers. Suppliers of seismic surveys include the market leader WesternGeco (which is a subsidiary of Schlumberger), Bergen Oilfield Services, Polarcus, Dolphin Geophysical and China Oilfield Services Ltd. (Rigzone, 2015). The seismic service providers have a large number of suppliers and sub suppliers. Companies like Schlumberger, Halliburton and Baker Hughes are engaged in virtually all upstream activities and is thus also a developer and supplier of the highly specialized equipment for gathering and analyzing the subsurface information.

The list of suppliers and sub suppliers, however, also includes less specialized companies. For the survey vessel the suppliers includes the shipyards which build and maintain the vessels. The shipyards (and operators) have other suppliers including equipment producers, which are not specific to the offshore sector but still provide inputs and after sales services to the sector. This includes suppliers of main engine, telecommunication, pumps, safety equipment, and boilers etc. which are on the makers' lists for any ship construction.

Exploratory drilling

If the seismic surveys and the subsequent analysis show signs of hydrocarbons the next step is to launch exploratory drillings. The E&P's will usually contract a specialized drilling contractor to make the wells. In some cases, however, the production companies can perform drillings in-house on certain fields.

The equipment used for the exploratory drilling varies depending on the location. In shallow water (up till 500ft) the drilling contractor usually uses a jack-up rig, which is placed on the seabed on three or four legs. On deeper water (500-10.000 feet) the drilling contractor will usually use a semi-submersible rig which can be partly lowered into the water as the drilling is ongoing. At even larger depths (up till 12.000 feet) the drilling contractor will usually use a drill ship. Because of their cargo-carrying capacity and mobility, drill ships are especially useful for drilling exploratory wells. Although they are not as stable as semisubmersibles in rough water, they can be moved from location to location much faster.

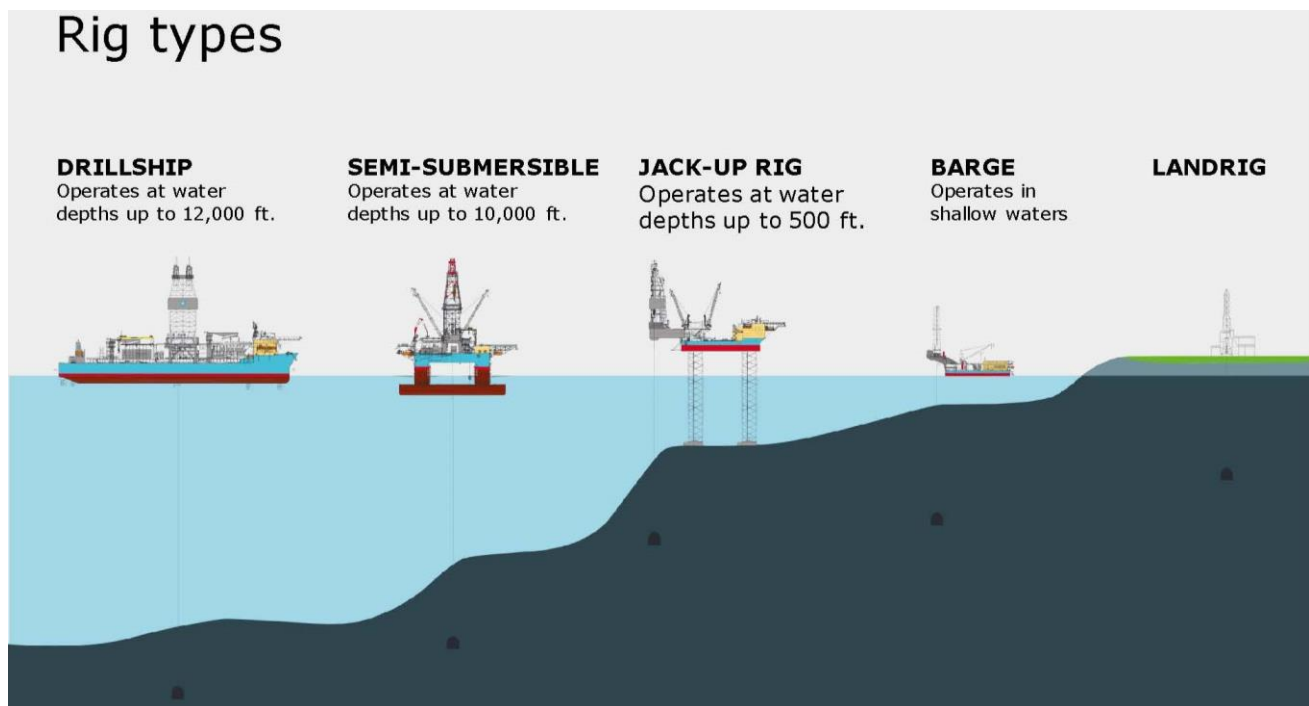


Foto:Maersk Drilling

During the exploratory drilling the drilling contractor obtains core samples of the underground, which are being analyzed by geologists for signs of hydrocarbons. The drilling contractor will usually drill several temporary wells – each taking a few months to complete. A positive find – called “a show” – is followed by more exploratory wells in order to assess the extent of the field, the reserves, the possible rate of production and the properties of the oil or gas. This is called appraisal drilling (Kaiser & Snyder, 2013).

The exploratory drilling phase involves a number of actors. The four largest drilling contractors actors are Transocean, EnSCO, Diamond Offshore and Seadrill which owned 36% of the 868 rigs in the world in 2012 (Snyder, 2013). Apart from the drilling contractor the E&P will often engage directly with various drilling specialists who perform a number of services, including well management (design, planning and operations), real time analysis (performance, monitoring and optimization), reservoir mapping (while drilling), tools and fluid systems services etc. (Schlumberger, 2015). This is performed by companies like Schlumberger, Baker Hughes and Ross Offshore. The operations furthermore require a number of logistic services including the movement of the rigs and supply services (by ship or air). This could be provided by a company like Mærsk Supply service. For safety reasons most drilling operations furthermore require stand-by service performed by companies like Borcos or Esvagt. The demand for stand-by services, however, varies with the national legislation and the safety policy of the individual E&P.

These actors all have a number of sub suppliers. The drilling contractor and the various service providers hired by the E&P's all have a number of specialized suppliers of drilling equipment all of which have several sub suppliers. The drilling rigs, drill ships, stand by vessels and supply vessels are built at different shipyards. The major constructor of jack-ups is Keppel Corporation, which has shipyards located in several locations. Most jack-ups are, however, constructed in Singapore. The drill ship market is dominated by Daewoo and Samsung which are both located in Korea and the construction of semi submersibles is mainly located in Korea, Singapore and China. Some drilling companies – like Mærsk Drilling – have in-house engineering departments while others use more standardized designs.

In addition to this the rigs and drill ships has to be upgraded and repaired. Most repairs and maintenance can be performed at local ports without shipyards or drydocks while more intensive upgrades require more specialized facilities. The dominant players in the repair and upgrade-segment are Lamprell and Keppel but the sector also a number of smaller players. Among the most important are SEMCO Maritime (DK), Signal International (US), Gulf Cooper (US), Drydocks World (UAE), Larsen & Toubro (Oman) Malaysia Marine (Malaysia), Maua Shipyard (Brazil), PD&MS (UK), Rijeka Shipyard (Croatia) and Remontowa (Poland) (Kaiser & Snyder, 2013).

The construction, maintenance and upgrades of the rigs include a vast number of suppliers and sub suppliers. Among the most specialized suppliers are the producers of drilling equipment and blowout preventers including National Oilwell Varco (US/Norway), MH Wirth (GER), GE Oil & Gas (US), Cameron (US). In both cases there are a large number of suppliers and sub suppliers.

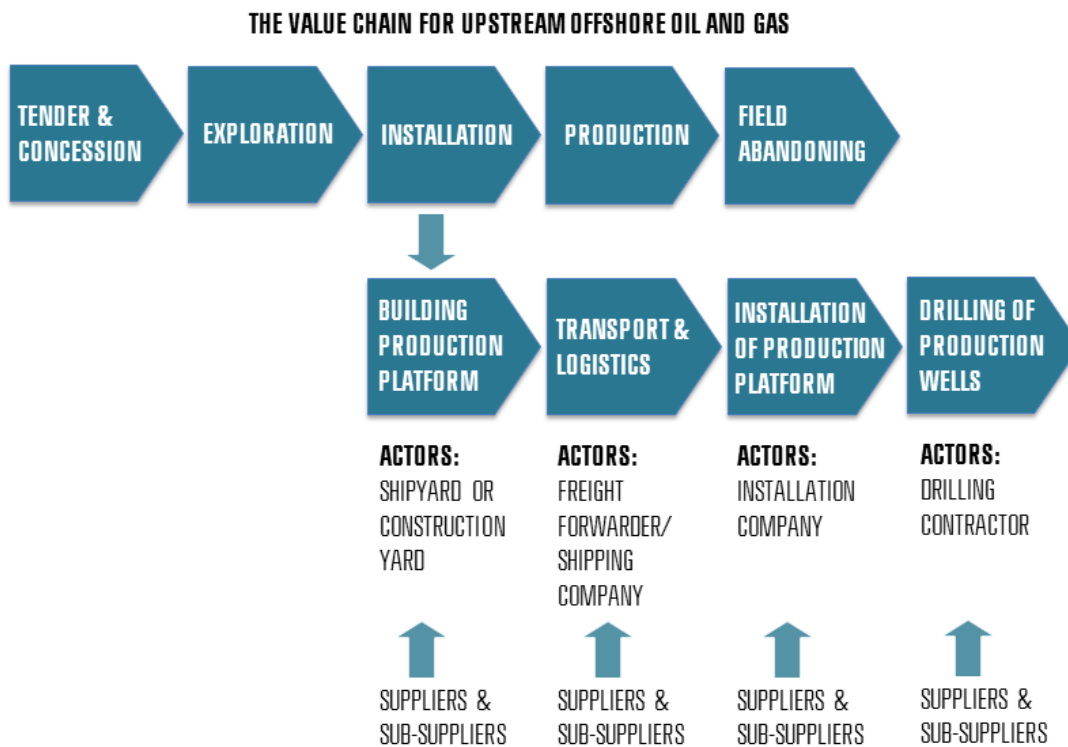
Among the more general suppliers are providers of safety equipment, pumps, steel sections, engines, electrical installations, telecommunication etc. which are also found on the makers list for ship constructions.

Commercial evaluation

Based on the seismic surveys and the exploratory drillings the E&P decides whether to commence production or abandon the field. The commercial evaluation takes several elements into consideration including the current and expected oil price, the cost of extracting the oil (depending on the environmental conditions, size and depth of the reservoir, and the type of underground). The E&P also has to decide if the field can be connected to existing infrastructure, or if new infrastructure has to be established. From these factors the expected lifetime and profitability of the production site can be calculated.

16 INSTALLATION

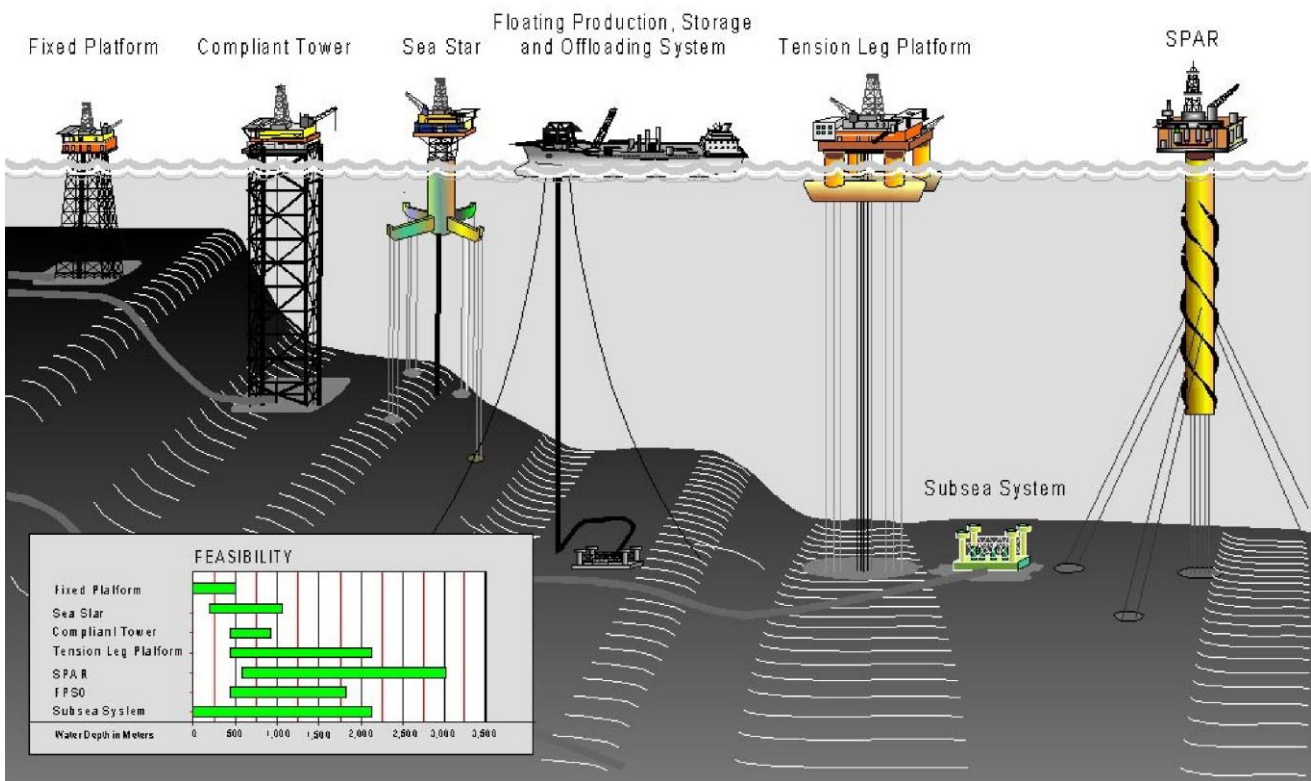
The installation phase generally consists of four main steps: (1) building the production platform, (2) transportation and logistics, (3) installation of the production platform and (4) drilling of the production well(s).



Building of the production platform

If it is decided to develop the field the E&P begins carrying out preliminary engineering. This includes deciding on a production concept (e.g. what type of rig or platform to use) and choosing contractors. These studies are often carried out by one or more engineering contractors or integrated engineering construction firms but may also be performed in-house by the E&P.

After the investment feasibility studies have been completed the E&P (or a subcontractor) will launch a detailed survey of the installation location in order to obtain the necessary data for the design, construction and installation of the production platform. Production platforms are usually very different from the drilling rigs. Where the drilling rigs are supposed to move from location to location, the production platforms are permanent constructions which are often fixed to a certain location for decades. As is the case with the drilling rigs there are several types of production platforms. The type of platform depends on the water depth, wave height and which equipment is necessary to perform the individual operation. The Fixed Platforms are usually installed for production on depths up to about 300 meters although they are most commonly used in depths less than 150 meters – e.g. in the North Sea area. Compliant towers are also fixed to the seabed but by a narrow, flexible (compliant) tower. These platforms are usually used at water depths ranging from 450 meters to 900 meters.



Source: Wikimedia Commons

Operations at greater depths are carried out from floating vessels. The Floating Production, Storage and Offloading System (FPSO) are vessels used to produce or receive hydrocarbons at depths up to 1800 meter. Most of them are converted supertankers. They are often used in frontier areas as they are easy to install and don't require pipeline infrastructure. The Tension Leg platforms are floating platforms anchored to the seabed. These platforms have pontoons which can be ballasted up and down by altering the amount of flooding in the buoyancy tanks. Tension Leg platforms can usually operate at depths up to 3000 meters. The Sea Star platforms are smaller versions of Tension Leg platforms. These platforms usually operate at depths up to 1000 meters. Subsea Systems are wells located at the seafloor. The well is drilled by a movable rig and the extracted oil and gas is transported by pipeline to a production platform or an onshore facility. The Subsea Systems are used at depths up to app. 2000 meters. Finally the Spar platforms are employed at depths up to 3000 meters. The platform is placed atop a huge hollow cylinder descending to a depth of 200 meters (Gerwick, 2007; Sadeghi, 2007; Maritime-connector.com, 2015).

The production of the production rig or production platform involves a large number of actors. To oversee and manage the complex series of contracts, the E&P will often set up its own management team or engage an external construction manager. In many cases the platforms are turn-key projects carried out by a construction company like Keppel, Hyundai, McDermott or Technip.

The next step is to develop the design of the substructure and the deck of the platform. This can be performed by the E&P, the contractor or by a third party, but often includes several actors. The design of the individual platform depends on a number of factors including operation depth, environmental factors (wave heights and wind strengths) and geotechnical data (seabed soil). After completion, the design has to be approved by the regulating authorities (and by the E&P) (Sadeghi, 2007).

The production of the substructure and deck is often performed onshore at a construction yard far from the installation site and involves the procurement and installation of the necessary process equipment. The construction phase thus

involves a large number of suppliers and sub suppliers including the construction yard and third parties (engineers, project managers etc.). Large rig shipyards exist in Singapore, China, India, South Korea, Russia, the United States, and the United Arab Emirates (Kaiser & Snyder, 2012). The construction yard furthermore has a large number of sub suppliers of equipment (specialized process equipment, pumps, safety equipment, steel constructions etc.) such as Schlumberger, ABB, Siemens, Wärtsilä and Rolls Royce many of which have representatives on the site (Sadeghi, 2007).

An example is the construction of the Technip TLP platform Shell Malikai. Technip was hired by Shell Offshore to manage the construction of the platform. The hull was designed by TMH which is a joint venture between Technip and MHB. The construction was carried out by Malaysia Marine and Heavy Engineering Sdn Bhd.



Foto: Scanpix/iris

Transportation and logistics

Upon completion the structures have to be loaded out and transported to the final assembly site. The transportation of the large sized elements is a complicated operation requiring special knowhow and equipment. These activities usually involve a number of actors including freight forwarders, offshore logistics companies and onshore base facilities. Freightforwarders include Blue Water Shipping which has handled complicated transfers of rigs through the Russian rivers and into the Caspian Sea. In many cases the transportation is performed on heavy lift vessels by companies like COSCO, AAL or McDermott. The offshore logistics company is in many cases present in several links of the value chain from construction to transportation and installation. The logistic providers have a number of suppliers (e.g. shipyards building and maintaining the ships) and sub suppliers (e.g. equipment producers, service providers etc.).

Installation of the production platform

Upon arrival at the assembly site the production platform is being assembled using a barge equipped with heavy lift cranes. This is often done by the logistics provider. Many production platforms are connected by a pipeline to a shore

terminal. In these cases the platform has to be connected to new or existing offshore infrastructure. The installation companies will often have the same types of suppliers as the logistics providers.



*Foto: Wikimedia Commons
SSCV Thialf installing the Spar platform Perdido in the Gulf of Mexico*

Drilling of the production wells

Following the completion of the production platform the drilling of the production well is commenced. This is usually done by a drilling contractor. A drill bit is attached to a drill string made of segments of drill pipe, each about nine meters long. The drill bit is lowered into the sea until it meets the seabed. The drill is rotated by a turntable at the platform floor, and as the drill grinds downwards (and sometimes horizontally) extra lengths of drill pipe is attached. For cooling, cleaning and stabilizing pressure, a “drilling fluid” is pumped through the drill pipe and out through nozzles in the drill bit at high velocity. The fluid is usually a mixture of water, clay, barite and chemicals. Back at the platform or drillship, the fluid is recycled through a circulation system that disperses the crushed rock and reuses the fluid. When the drill reaches target depth, production casing is lowered into the well and cemented into place. At the bottom of the well small explosive charges are used to make small holes which allow the oil or gas to flow into the well while controlling pressure. In many cases production start after a few wells are completed with concurrent drilling continuing. During the production phase, new wells must be drilled from time to time in order to ensure the continuing productivity of the well. Subsea satellite wells may be tied to the primary platform.

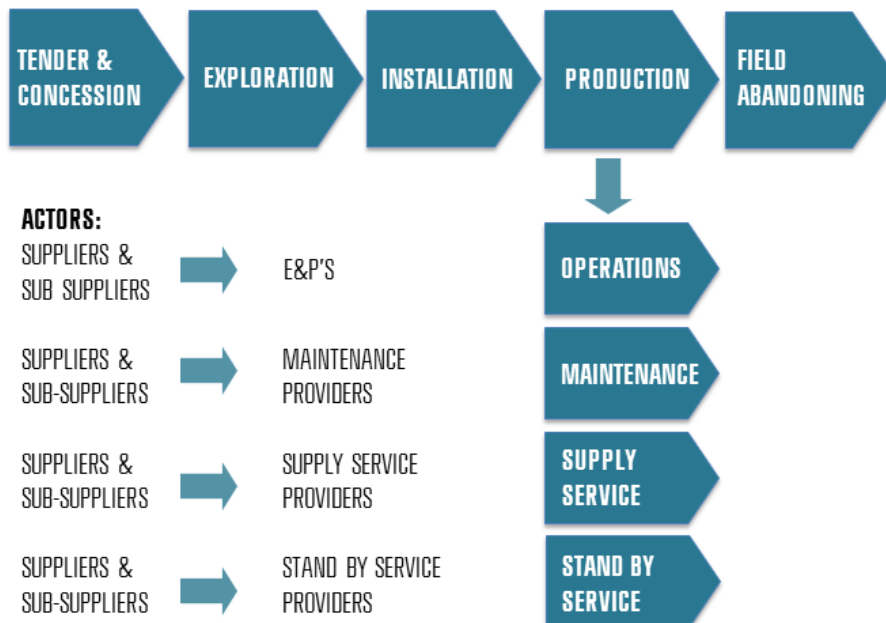


*Foto: Maersk Drilling
The drill ship Mærsk Viking*

PRODUCTION

In the upstream oil and gas value chain the production phase is by far the longest. It is not uncommon that it can last between 20 and 40 years or more. Apart from the actual operation of the production platform the production phase also includes a number of support activities including maintenance, supply service & logistics and stand by service.

THE VALUE CHAIN FOR UPSTREAM OFFSHORE OIL AND GAS



Operations

The daily operations basically involve the extraction of the oil and gas from the underground. This activity is performed by the E&P's. In many cases several E&P's own a share in an oilfield to share and distribute risks. The operator responsible for the production is usually the largest shareholder. The E&P is often supported by contractors performing specialized engineering solutions, well monitoring, well management, safety management etc. In many oilfields drilling contractors are hired to make additional wells. All of these suppliers have a number of sub-suppliers, which provide equipment, maintenance and training etc.

The production phase can be divided into two main stages. At the initial stage the pressure from the subsurface is sufficient to push the hydrocarbons to the surface. At the later stage, however, the E&P usually has to inject water or gas into the reservoir to press the oil and gas to the surface. In some cases, compressed air or steam is sent down a well to heat the remaining petroleum, which also increases pressure. The liquid that rises up to the platform is a mixture of crude oil, natural gas, water and sediments. On the platform the gas and oil must be separated. Produced water and sand must be separated out, with the water requiring treatment before being discharged into the sea. The production platform is equipped with a flare stack, which is used for burning off flammable gases released during unplanned over pressure of the plant equipment. For safety reasons flaring can also be used to get rid of "waste gas" which is brought to the surface along with the oil. This is especially the case in remote areas that lack the necessary infrastructure to transport the gas to the shore facilities. For environmental reasons the flaring of gas is often limited by regulation to the initial period and to emergencies. The platforms are usually also powered by some of the gas which has been extracted.

Once extracted the hydrocarbons are usually transferred to a shore terminal through a pipeline. In remote areas without connecting infrastructure the hydrocarbons are often shipped by a shuttle tanker. In this case a pipeline runs from the platform to a loading buoy for direct transfer (Gerwick, 2007).

The largest offshore platforms are often operated by more than 100 workers. Many offshore facilities are thus basically cities at the sea. Most offshore facilities include living quarters, but sometimes multiple platforms are needed, in which cases footbridges connect drilling, injection, storage, treatment and living spaces on separate structures above the water.

Maintenance

Most production platforms operate in 20 to 40 year. During their lifetime they need to be maintained, repaired and upgraded. Systematic repairs and maintenance improve the safety for the personnel, the environment and prolongs the operation life-time of the platform. It furthermore reduces down-time which is extremely important as interruptions in the oil supply due to unscheduled platform shutdowns are very costly. And finally the upgrades increase efficiency as new and better equipment is applied during the lifetime of the platform.

Daily maintenance is usually carried out by the E&P's. The technicians operating the platform thus have the necessary competences and skills to conduct first-line maintenance and ensure a safe and stable production. Special repairs or maintenance tasks and larger upgrades are, however, normally performed by contractors. These include a vast number of different actors, e.g., project engineering companies, heavy construction contractors, divers and ROV operators, rope access teams, and various equipment manufacturers. In either case there are a number of sub suppliers including equipment producers, logistics providers etc.

Supply service & logistics

The offshore supply vessels are an important part of the logistics chain involved in the production of oil and gas. Almost all goods and equipment needed on the installations is transported by supply vessels. Helicopters are also used to some extent for personnel transfer, but this type of transportation is much more expensive than by ship. The activities in the logistics chain are to a great extent controlled and coordinated by the E&P's, but they involve several external actors.



Foto: Scanpix/iris

The shipping companies, which operate the supply vessels, provide the link to the shore. These services are provided by companies like Mærsk Supply Service (DK), Royal Wagenborg (NL) and Northern Offshore Services (S). Apart from transporting personnel and equipment these companies often provide a range of other services including anchor handling, rig movement, and support with various installation tasks. These shipping companies have a number of other suppliers including the shipyards which build and maintain the vessels, third part engineers, ship management companies etc. All of these companies have other suppliers. The shipyards thus have a number of equipment suppliers (pumps, safety equipment, engines, telecommunication, navigation equipment etc.) which are also suppliers to other shipping segments.

The supply service also includes activities performed onshore by port operators and logistics suppliers. The ports can be publicly owned but most supply companies are private ventures. In the Danish part of the North Sea the publicly owned Esbjerg Havn is the main port for servicing the offshore sector, while a company like Danbor is a major private provider of port logistics for the oil and gas sector.

These actors – ports and logistics providers – have a number of suppliers and sub-suppliers providing a range of services (stevedoring, pilots, tugs etc.) and producing and maintaining facilities and equipment (piers, cranes, trucks, warehouses, pilot and tug boats etc.).

Finally, a number of actors are engaged in the inland transportation of the equipment to the port facilities. These include freight forwarders, truck companies and other logistics providers – all of which have a number of suppliers and sub suppliers (Antonsen, 2009).

Stand-by service

Accidents at offshore installation can potentially be very serious to the workers and the environment. In order to secure the safety for the workers, the aquatic life and the environment, most countries demand the presence of stand-by vessels near offshore installations. The stand-by vessels make sure that passing ships do not collide with the installations, and they rescue workers that fall overboard from the rigs and platforms. They can furthermore engage in oil spill recovery and, if needed, they can aid in evacuation of the offshore installation (Poulsen & Hahn-Pedersen, 2011; Christou & Konstantinidou, 2012; Hahn-Pedersen & Guldborg, 2006).

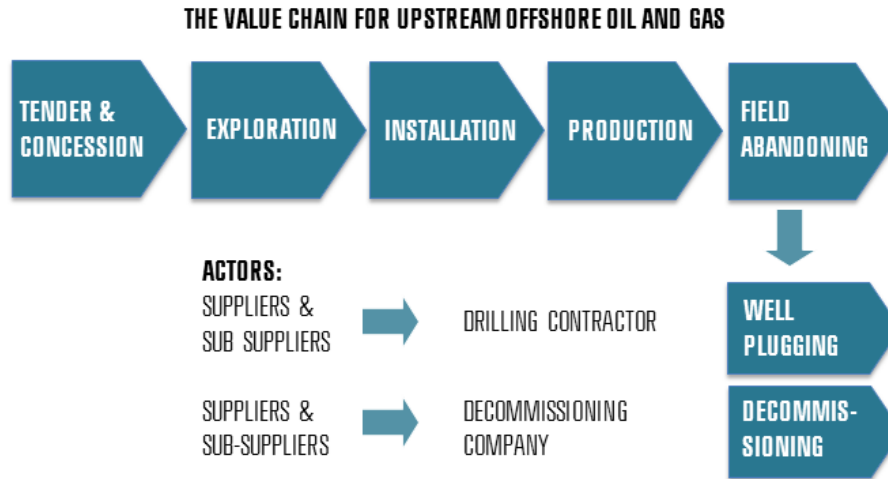


Foto: Scanpix/iris

Stand by services are usually performed by specialized offshore shipping operators like Esvagt (DK), Borcos Shipping (Malaysia), Northern Offshore Services (S) or Carina Offshore (South Africa). Apart from stand by services these companies often perform other services for the E&P's including rig movements, transfer of equipment and personnel etc. The providers of stand-by services have a number of suppliers. In several cases the crew is provided by ship management companies which train and provide seamen. The ships are built and maintained by various shipyards. Esvagt, which is a major stand-by service operator in the North Sea, are currently building its most complicated ships in Norway while the more standardized vessels are being constructed in Asia. Maintenance is usually performed near the site of operation (interview with Thomsen). The suppliers also include a vast number of maritime suppliers (pumps, safety equipment, engines, telecommunication, navigation equipment etc.) which provide and maintain the equipment. These companies are not exclusive to the offshore sector but are considered part of the general maritime supply industry.

FIELD ABANDONING

When the field has reached the end of its economic life – usually after 20-40 years – the regulations of most countries require that all facilities must be removed (Gerwick, 2007). This phase includes the plugging of the wells and the decommissioning of the platform.



Decommissioning

The decommissioning phase usually starts a couple of years before the well runs dry. The E&P (and/or an external consulting company acting as project manager) will initially draw up a decommissioning plan. This includes a review of the contractual obligations and a detailed analysis of the decommissioning process based on a site survey and engineering evaluations.

The next step is to obtain the necessary permits from the local authorities. This includes an environmental evaluation of the consequences. The E&P will usually contract with a local consultant, which is familiar with the regulatory framework.

Finally the E&P (or project manager) will begin to engage a number of contractors which specialize in various parts of the decommissioning process (e.g. cutting, engineering, project management, diving service, barge operations etc.).

To prepare for the decommissioning the tanks, process equipment, pipes, etc. are cleaned and removed. This process includes cutting pipes and cables between the decks, separating the modules and preparing the sections for liftoff.

Well plugging

Before the actual decommissioning can commence the wells have to be plugged. This is usually done by a drilling contractor. The actual decommissioning is usually performed by a decommissioning company. The top of the platform is taken apart and lifted onto a barge. The next step is to remove the jacket. This is often the most expensive part of the process. Divers cut the piles before the jacket is removed in one or more pieces depending on the size.

Pipelines or power cables may be decommissioned on the site, as long as they don't pose an environmental hazard or interfere with navigation or fishing operations. In these cases, the pipelines are flushed with water before they are disconnected from the platform. The open end is plugged and buried and covered with concrete.

After being returned to shore the platform is taken apart and the materials are recycled or scrapped. A post decommissioning survey is then performed at the site to identify and map the location and quality of debris left behind during the decommissioning process and notes any environmental damage. Finally ROV's (Remotely Operated underwater Vehicles) and divers are deployed to identify and remove any debris that could interfere with other uses of the area.

The decommissioning phase thus includes a number of suppliers. These include consultant engineers, project management, divers, ROV companies, drilling contractor, decommissioning contractors (performing the disassembly and

transportation of the platform), port facilities, inland transportation, scrapping and recycling facilities to mention a few. These suppliers all have a vast network of sub suppliers depending on their activities.



Foto: Scanpix/iris

THE VALUE CHAIN FOR OFFSHORE WIND

The value chain for offshore wind has strong similarities with the upstream activities of the offshore oil and gas value chain. The activities include field development, tender and concession, installation, production and finally decommissioning. The main actors in the value chain are (1) the developers and energy companies who operate the windfarms, (2) the turbine manufacturers, which play an important role in development, production and operation, and (3) the states, which provide the regulative framework, investments and subsidies.

Measured by the share of installed capacity in Europe in 2014 the major developers include Dong Energy (24,1%), Vattenfall (10,5%), RWE (8,7%), E.ON (7,3%), Centrica (5,5%), SSE (5,3%), BARD (4,8%), WindMW (3,6%), Iberdrola (2,2%), Stadtwerke München (2,1%), Statoil (1,8%), Statkraft (1,7%) while the remaining 22,4% are divided among smaller actors (Corbetta & Mbistrova, 2015).

The largest turbine manufacturers measured by installed MW in Europe in 2014 include Siemens (65,2 %), Vestas (20,5%), Senvion (6,6%) and BARD (5%) with the remaining share divided on smaller manufacturers (Corbetta & Mbistrova, 2015). Developers, energy companies and turbine manufacturers are supported by a wide range of suppliers and sub suppliers which make up complicated value chains in their own right.

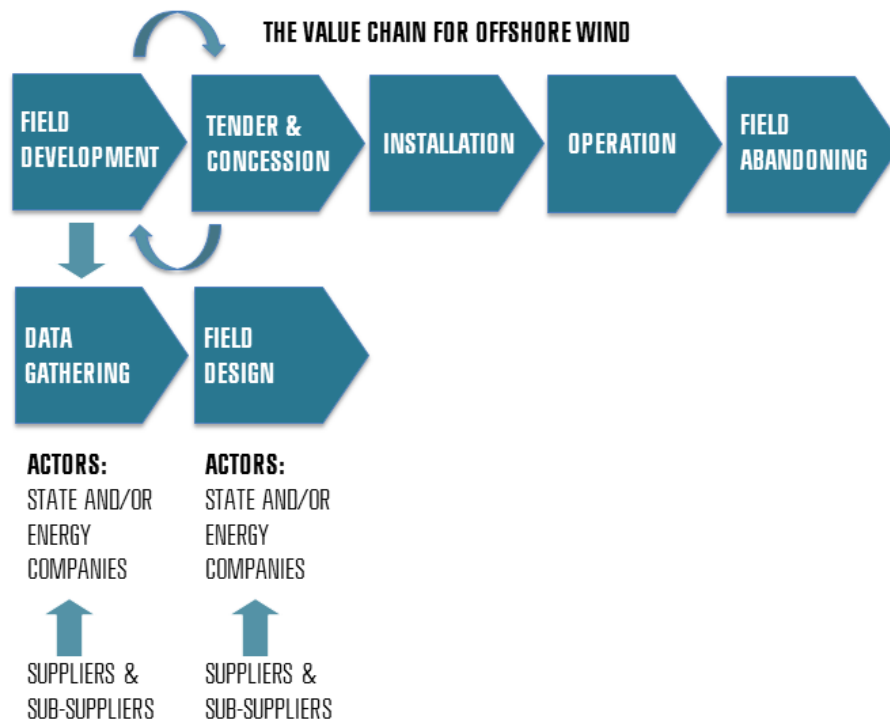
Finally, the state is an important actor. Wind energy is generally more expensive to produce than energy produced from fossil fuels, and it would need very high prices on fossil fuels to make wind energy competitive against conventional plants. It is thus clear that there would be little investments in wind energy without direct and indirect subsidies from the states. The states have two major reasons to promote wind energy: (1) Increased concerns about environmental issues such as global warming and local air quality means that several states aim at reducing the emission of carbon dioxides, and (2) by becoming an energy producer the state becomes less dependent on imports of fossil fuels.

Wind energy from offshore installations is generally more expensive than energy produced from onshore wind farms due to higher construction, installation and maintenance costs. Laying a foundation for an offshore wind station is thus 50% more expensive than for a land based installation. Subsea cables are more expensive than overhead transmission lines and the distance to the transmission system is often longer (Haggett, 2008; Green & Vasilakos, 2011).

There are, however, three reasons for governments to promote the establishment of windfarms offshore instead of onshore: (1) The offshore windfarms are more productive than onshore farms due to the stronger and steadier wind conditions at sea; (2) the establishment of offshore windfarms creates fewer inconveniences (visual effects, noise etc.) as they are usually placed far from populated areas; and (3) the space available for the establishment of windfarms is much larger offshore than onshore (Green & Vasilakos, 2011).

FIELD DEVELOPMENT, TENDER AND CONSESSION

The value chain for offshore wind energy begins in the national parliament. For the reasons mentioned above the politicians will decide on long term goals for production of sustainable energy and promote this through regulations, subsidies and direct investments.



The preliminary phase includes the operators (the developers & energy companies) and the energy authorities (the state). The state owns (and promotes) the right to exploit energy from water and wind within the territorial waters, and in order to establish an offshore windfarm the energy companies need to obtain permission from the relevant authorities. This process varies from country to country depending on the national legislation.

Under the concessionary system the developers/energy company enters into an agreement with the government to have the exclusive right to operate, maintain and carry out investments in a public utility for a given number of years. The developers/energy companies can obtain permission through (1) a government call for tenders or (2) an open door application. A government call for tenders is carried out to realize a political decision to establish an offshore windfarm in a specified area and of a specified size. In the open door process the applicant chooses the construction site.

Field Development

The first step in the value chain is to perform preliminary surveys in order to define the areas for development. In an open door process the applicant will have to apply for an investigation permit in order to perform the surveys. In a government project the surveys are often conducted by the authorities which contract the task to one or more specialized subcontractor(s). The surveys include an assessment of environmental impacts, visual consequences, consequences for fishery and navigation, a geophysical survey, detailed information about wind, wave and current conditions and an analysis of possible grid connection solutions (Danish Ministry of Climate, Energy and Building, 2012).

The surveys are usually contracted to a number of specialized data acquisition companies. At the Horns Rev windfarm – situated 14 kilometers west of Blåvandshuk – the Danish state (energinet.dk) contracted with Orbicon A/S (Denmark) to make the underwater noise modelling. Orbicon later sub-contracted with Subacoustech Environmental Ltd (UK). NIRAS (Denmark) was hired by energinet.dk to perform a UXO-study which comprises the collection of information and data relating to unexploded ordnance (UXO), and the assessment of risk of UXO incidents in the site. Energinet.dk contracted with SSE (Sweden) to conduct a geotechnical site investigation at the site and SSE sub-contracted GEO (Denmark) to perform the technical investigation. Energinet.dk contracted GEMS Survey Limited (Poland) to conduct hydrographic and geophysical seabed surveys at the site and associated cable route. Wind calculations involved data from Tech Wise (Denmark) processed by the Technical University of Denmark (DTU Wind Energy) and validated by DEWI (Germany). Wave calculations were provided by DNV-GL (Det Norske Veritas-Germanischer Lloyd) (Norway & Germany). The

developer Energy E2 (today DONG Energy) furthermore contracted with the Danish National Environmental Research Institute to produce a technical report on bird issues (Energinet.dk).

The example above shows that a number of very specialized actors – public and private – are engaged in the survey process. All of these actors have a number of suppliers of vessels and equipment. These suppliers include the shipyards which build and maintain the survey vessels and a vast number of subcontractors (equipment manufacturers etc.). All of these are usually considered to be a part of the general marine supply industry. The wildlife surveys are often carried out by an aircraft operator which has suppliers and sub suppliers (construction, maintenance, spare parts, operation, airports etc.). Another example of a service performed by a supplier or sub supplier is the design, installation and operation of meteorological stations collecting data on wind and waves (BVG Associates, 2014).

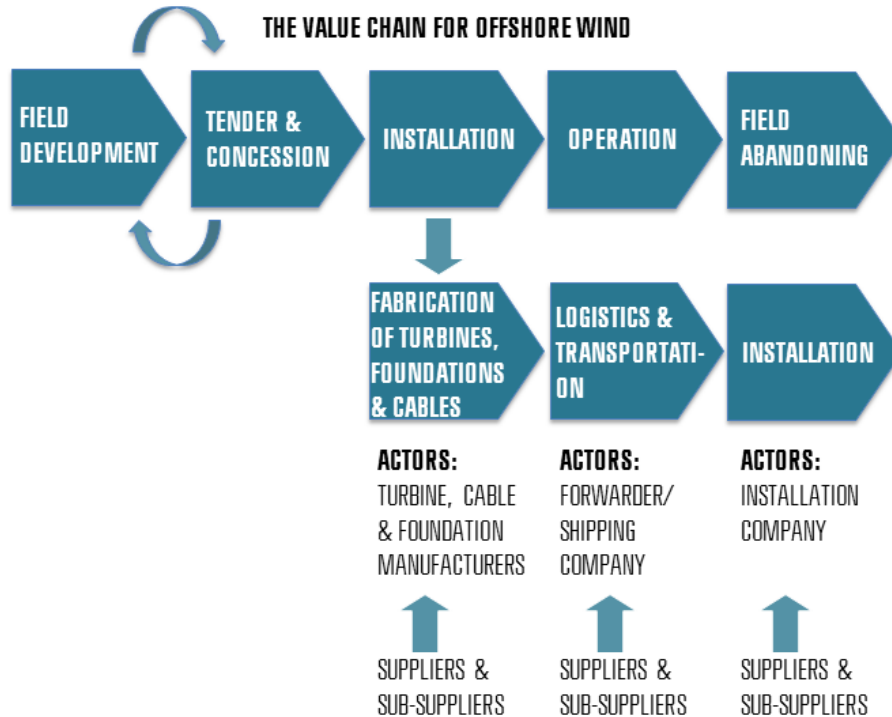
Windfarm design

If the preliminary surveys are approved by the authorities the operator can begin planning the wind farm in details. The planning process is usually carried out by the energy company assisted by external project developers/project managers and the turbine manufacturers. The process furthermore involves consultant engineers performing foundation design, cable routing, substation design, design of power systems, wind farm array design etc. (BVG Associates, 2014).

Whether in a government tender or an open door process the energy company needs to apply for an installation permit. This application includes a detailed description of the project (including a project schedule, detailed mapping, documentation of mills and foundations, lists of suppliers, security procedures, insurance information etc.). In a tender, the concession rights are usually awarded to the applicant who offers to produce energy at the cheapest price under the given conditions. After the installation permit is obtained the installation process can commence. In a tender, the government will usually connect the windfarm to the shore installation. In an open door process the operator has to secure connection to the shore. Finally – when the turbines are ready to be installed on the foundations – the operator needs a permission to produce energy. In order to obtain this, the operator has to document that the terms in the construction permission have been fulfilled (Danish Ministry of Climate, Energy and Building, 2012; Andersen & Drejer, 2012; BVG Associates, 2014).

INSTALLATION

After the preliminary surveys and field design have been completed and the energy company has obtained the necessary permissions the installation phase can commence. This phase basically includes three activities: (1) the production of the hardware (cables, windmills and foundations), (2) the logistics and transportation to the installation site and (3) the installation of the foundations, windmills and cables.



Production of wind turbines, platforms, cables and foundations

The manufacturing of the turbines involves a number of suppliers and represents individual value chains in its own right. The central actor is the turbine manufacturer, which make the overall design and also design and produce several components (Andersen & Drejer, 2012; BVG Associates, 2014).

The windmill consists of several components, including blades, gears, generators, convertors, towers, bearings, electronic control systems and other nacelle components. The overall design of the windmill is carried out by the turbine manufacturer and external design houses while the design of the components also includes the relevant suppliers. The manufacturing process is either performed in-house by the turbine manufacturer or outsourced to suppliers and sub suppliers. Blades are usually manufactured in-house even if some use suppliers. Towers are mainly manufactured by suppliers.

The manufacturing of the foundation is usually contracted to specialized steel constructions and steel engineering companies while subsea cables is usually contracted from an individual cable supplier. The largest foundation providers measured by the share of foundations installed in 2104 include Bladt (43,7%), Sif (24,9%), EEW (17,9%), Smulders (11%), Aker Verdal AS (1,6%) and Siag (0,9%) (Corbetta & Mbistrova, 2015). The major cable suppliers include Nexans, Prysmian, JDR, Parker Scanrope, NSW, NKT, LS Cable & Systems and ABB (Corbetta & Mbistrova, 2015). Finally, the manufacturing phase includes the production of grid connection platforms to secure the connection between one or more windfarms and the onshore installations.

Transport and logistics

Upon completion the foundations and turbines have to be transported from the factory to the installation site. The transportation of the large sized elements is a complicated operation requiring special knowhow and equipment. As the

process often includes several modes of transportation it is often being arranged by a freight forwarder. If the manufacturing site is situated far from the sea the structures are usually transported to the port on special trailers. This is usually carried out by a specialized haulage contractor.

At the port the structures are unloaded and in many cases also stored and/or further assembled. This requires a wide range of services from stevedoring to equipment and warehouse facilities. Many ports have specialized in facilitating shipping of offshore wind turbine equipment. The services can, however, also be performed by the freight forwarder or by other logistics providers. If further assembly is required at the port this is usually carried out by the manufacturer.

Finally the structures have to be transported from the port to the installation site. This is usually done by a specialized shipping company operating a purpose built fleet of heavy lift vessels. The shipping company has a number of suppliers (e.g. shipyards building and maintaining the ships, ship management companies training and certifying the crew etc.) and sub suppliers (e.g. equipment producers, service providers etc.).

Installation

At the installation site the installation of the foundations, turbines and grid connection platforms are carried out by specialized installation shipping companies – the largest of which is A2Sea (Denmark). The foundations are either installed by a jack up vessel or a heavy lift vessel. The jack up vessel will usually have the foundations on the deck, while a heavy lift or crane vessel will need a barge to carry the foundations. The turbines can, however, only be installed using a jack up vessel as this gives the necessary stability for the lifts.



Foto: www.siemens.com/press

A nacelle for a Siemens SWT-3.6-120 wind turbine being mounted on the tower by a crane.

Cable installation is performed by a number of contractors such as CT-Offshore (Denmark) or Blue Offshore (Netherlands). In order to prevent damage from anchors and fishing devices the cables are buried two meters below surface with a jet plow. Unlike turbine installation, cable installation does not demand purpose built vessels and the cable installation fleet is mostly made up of older vessels built in shipyards around the world. Some of the windmill installation

shipping companies also install cables. The windfarm developers are, however, increasingly looking to combine the supply and install packages to reduce the number of contractual interfaces. Where a supply and install contract is awarded, it is most likely that the main contractor is the cable supplier, most of which have some internal cable-laying expertise. Even if separate packages are awarded the developers will make a contractual obligation on suppliers to work together (Andersen & Drejer, 2012; BVG Associates, 2014; Januário et al., 2007).

One or more grid connection platforms are installed to secure the connection between the windfarms and the onshore installations. These installations are developed by companies engaged in power generation – e.g. Siemens (Germany) and Alstom (France). Finally, hotel vessels are often used to accommodate technicians during the installation phase in order to reduce the time used for transportation to and from the installation site. Offshore accommodation services are provided by companies like C-Bed (Netherlands) or Blue Water Shipping (Denmark). Accommodation ships are usually old ferries with large overnight accommodation.

The shipping companies providing installation- and accommodation services have a number of more general maritime suppliers. Ship management may be outsourced to specialized sub suppliers like NT Offshore (Denmark) or FleetPro (US) which provide services for several operators. The list of suppliers also includes shipyards building and maintaining the ships. Installation vessels are increasingly being built in Asia but they are maintained near the area of operation (mainly in Northern Europe). Sub suppliers include equipment producers and various service providers.

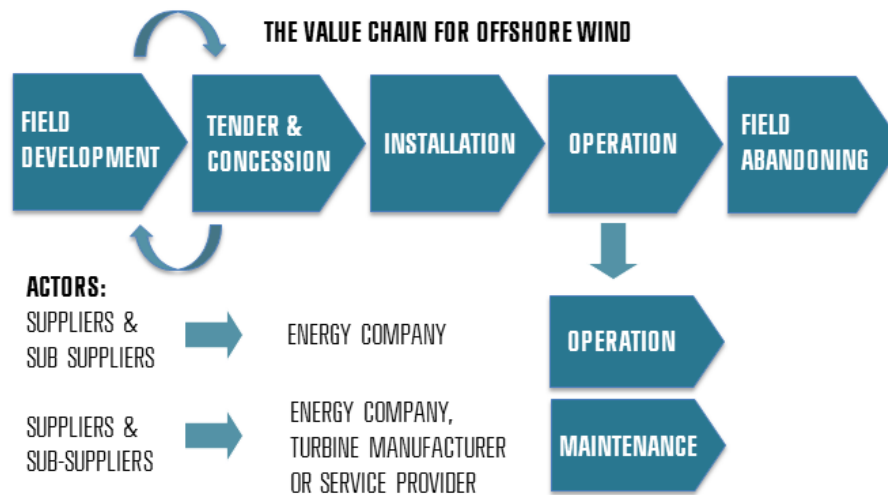


Foto: www.siemens.com/press

The heavy-lift crane ship Thialf during the installation of the HelWin2 platform. The HelWin2 grid connection will transmit offshore-generated wind power to land for some 700,000 households.

32 OPERATION

Once the installation is completed the windfarm can begin producing electricity. Most windfarms have a commercial life length of 20-25 years (Smith, 2014). During this period, the daily operation, maintenance and minor services can be carried out by (1) the turbine manufacturer, (2) the energy company, or (3), a third party service provider. The grid connection is often managed by electricity transmission system operators like Energinet.dk (Denmark), Svenska Kraftnät (Sverige), Tenne T (Netherlands) etc.



Most offshore wind turbines are currently in warranty or under a long time service agreement with the turbine manufacturer. In a few cases, however, the energy company has decided to perform maintenance etc. in-house. These companies have established the necessary in-house expertise and use specialist third party service providers when necessary (for blades, gearboxes etc.). Most energy companies are expected to continue to purchase offshore maintenance from the turbine manufacturer given the additional level of risk associated with the technology (BVG Associates, 2014). Third party service providers will however often be engaged in sub surface maintenance of foundation and cables. This include ROV operators, commercial divers etc.

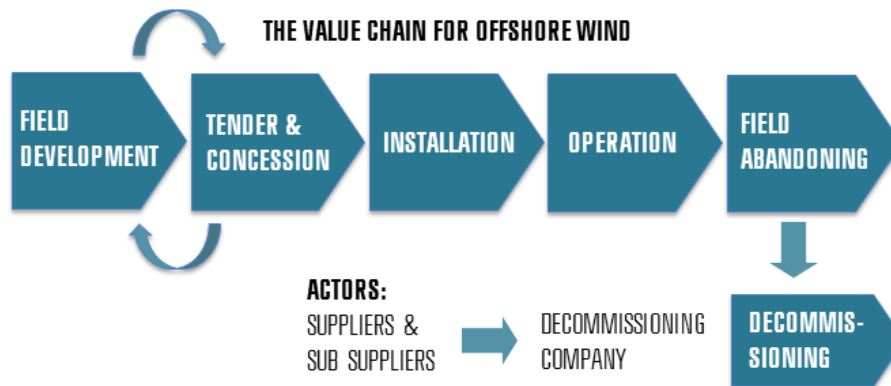
As the wind farms are established further and further from shore the accommodation and the transfer of crew, equipment and supplies have become an increasingly important element in the daily operation. There are basically two types of supply vessels: (1) personnel transfer vessels and (2) offshore support vessels. Personnel transfer vessels are usually used for windfarms near shore. The vessels are usually between 14m and 24m and carry up to 12 technicians as well as basic equipment. The offshore support vessels are larger ships which are stationed at windfarms far from shore. They are typically equipped with advanced personnel access systems, cranes, workshops, a helideck and accommodation for about 50 people (BVG Associates, 2014).

For major refitting's, such as replacement of turbine blades or gearboxes, larger vessels are usually needed. These vessels are usually the same jack-up vessels, which are being used for installation.

Apart from the energy companies, the turbine manufacturer, third party service providers and specialized offshore support and supply shipping companies (all of which have a number of suppliers and sub suppliers) there are a number of in-land suppliers. These are basically the same as has already been mentioned in the transport and logistics section; namely the ports, haulage contractors & freight forwarders (all of which have different suppliers and sub suppliers).

FIELD ABANDONING

The decommissioning of an offshore windfarm is basically the reversal of the installation process: It includes removing the electrical infrastructure, removing the rotor, the nacelle and the tower. The foundations are often sunk tens of meters below the seabed and are thus difficult to remove. Monopile foundations will usually be cut off 2 meters below the seabed level while gravity base foundations are often impossible to remove. Whether the cables have to be recovered depends on the national legislation. (Januário et al., 2007; Department of Energy & Climate Change, 2011).



Compared to the decommissioning of oil and gas installation it is thus fairly simple. The decommissioning process basically requires the same equipment and actors as the installation process. The disassembly of the turbines and the recovery of foundations and cables is performed by the operators of jack-up vessels, heavy lift ships and/or barges. In the port a number of other actors take over including stevedores and port authorities. Haulage contractors and in some cases freight forwarders take care of the inland transportation to the final destination. Some components might be reused in other turbines. The steel which make up the majority of the structure can be recycled. The blades are, however, usually made of composite materials which are difficult to recycle. This process involves a number of actors including the scrapping yards, steel mills, and in some cases turbine operators and manufacturers.

The market for decommissioning of offshore windfarms is rapidly growing. The first generation of wind farms is becoming technologically outdated and will be retired in a few years. Over the next decade many more will follow (Gjøvad, 2014).

HOW OFFSHORE SUPPLIERS POSITION THEMSELVES IN THE VALUE CHAIN(S)

When examining how offshore suppliers position themselves in the value chain there are four main elements to consider: (1) the type categorizes the supplier as a specialist or as a generalist. The specialist is totally dependent on one sector (e.g. offshore oil and gas) while the generalist is usually a supplier to several sectors (e.g. shipbuilding, power plants, offshore wind, and offshore oil and gas). (2) The activity refers to the links of the value chain in which the supplier is situated. A supplier can thus be engaged in very few activities in the value chain or in a number of activities. (3) The level determines if the supplier is direct supplier, sub supplier or 3rd tier supplier to the energy company in the actual link(s) and (4) service refers to what type of services the supplier provide in the individual link.

HOW OFFSHORE SUPPLIERS POSITION THEMSELVES IN THE VALUE CHAIN(S)

TYPE:

Generalist i.e. positioned in several value chains or *Specialist* i.e. dependent on one value chain

ACTIVITY:

In what link(s) of the value chain(s) the company is positioned

LEVEL:

Where the company is positioned in the link(s) i.e. direct supplier, sub-supplier or 3rd tier supplier

SERVICE:

What type(s) of service the company performs i.e. equipment manufacturer, service, logistics etc.

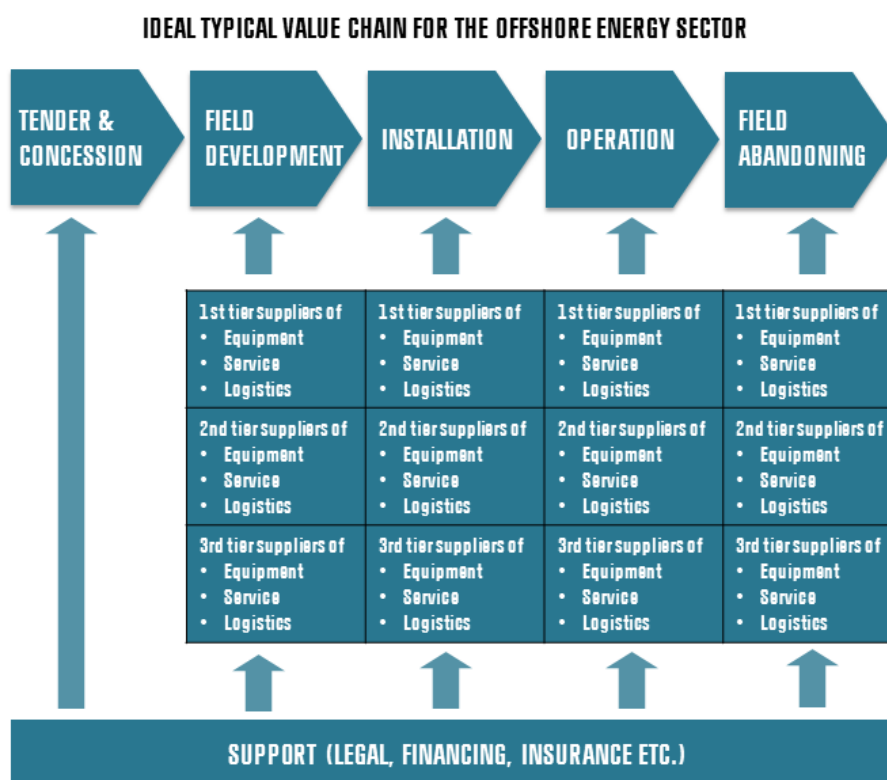
The value chains for offshore oil and gas and for offshore wind have a number of similarities and differences. Both sectors are driven by the demand for energy and both sectors depend on maritime infrastructure, equipment and competences (ports, ships, divers etc.) for a number of activities (installation, supply and maintenance etc.). The sectors are, however, also extremely specialized. The first extracts resources from the underground, while the latter produces energy from the wind. The similarities and differences mean that some suppliers are extremely dependent on one sector (turbine producers to the wind energy sector or drilling contractors to the oil and gas sector). These companies can be characterized as specialists. Other suppliers provide services to several sectors (shipyards constructing and maintaining supply vessels, shipping companies operating the supply vessels, pump producers, producers of safety equipment etc.). These companies can be categorized as generalists.

Over a lifetime the two value chains they have a number of activities in common. Both include (1) a tender and concession phase where the energy company obtains the right to explore and produce energy from the authorities. (2) An exploration phase where the physical location is examined and the installation is planned. (3) An installation phase where

the equipment is produced and transported to the site where it is installed. (4) An operation phase where the energy is produced or the energy source is extracted and (5) a decommissioning phase where the field is abandoned.

This value chain is used as an ideal typical model for the offshore energy sector. As already mentioned each link includes more detailed value chains with extensive differences between the activities and actors in the two value chains. Each link in the value chain has different levels of suppliers and sub suppliers depending on the activity. The suppliers can be divided into various levels depending on whether they are direct suppliers (1st tier), sub suppliers (2nd tier), third tier suppliers etc. to the energy company (Balance Technology Consulting, 2014).

The suppliers provide a number of services, which can be divided in to more or less detailed categories. This report distinguishes between: (1) equipment manufacturing and assembly, (2) services (which include hands on service like maintenance & installation and knowledge service like design & engineering), and (3) logistics providers (which include transportation, freight forwarding services etc.).



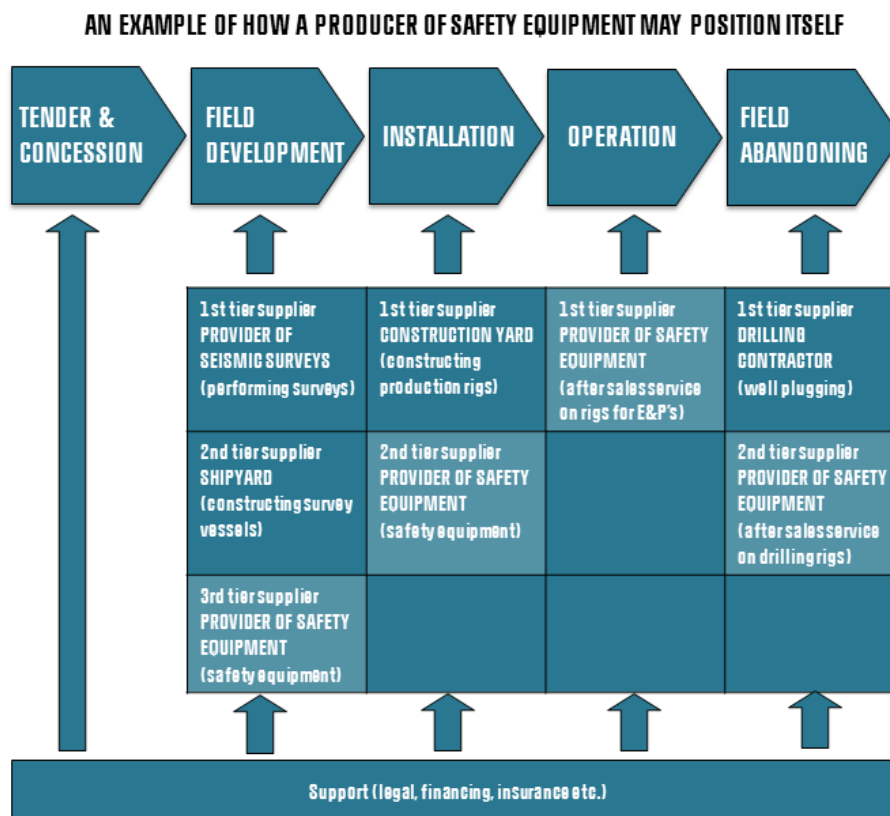
The value chain is extremely complex. A supplier will often be positioned (1) in several links of the value chain(s), (2) at various levels, and (3) with a variety of services. In the field development phase a supplier of safety equipment may thus be positioned as a 3rd tier supplier for a shipyard building the survey vessel (2nd tier supplier). The shipyard delivers the ship to the geo-survey company (1st tier supplier), which perform the geo survey task for the E&P. The supplier of safety equipment is furthermore a 2nd tier supplier in the installation phase as it produces safety equipment for a production platform (In this case the 1st tier supplier is the construction yard which constructs the rig for the E&P). The provider of safety equipment is, however, also a direct supplier to the energy company in the operation phase as it provides after sales service on the installed equipment. This is obviously highly simplified example. In reality there are a number of individual value chains within each link and the supplier may position itself differently in each of them.

Most offshore suppliers are thus positioned in several links of both value chains at various levels and providing a variety of services. By integrating forward a supplier can position itself closer to the energy company (e.g. 2 tier supplier also

becoming a 1st tier supplier) and by integrating backward the supplier can control the sub supply level (e.g. a 2 tier supplier also becoming a 3rd tier supplier).

A supplier can furthermore create new market positions in the value chain. The increased servitization is a good example, as traditional manufacturers (often 2nd or 3rd tier suppliers) have begun to provide after sales services, and have thus become direct suppliers to the energy company in the operation phase.

Finally a supplier can be positioned at different levels of the same link in different countries. A supplier can thus be a direct (1st tier) supplier to the energy company in one country but need to go through a local contractor (as a 2nd tier supplier) in another – even if the provided service is exactly the same in both cases.



FACTORS DETERMINING VALUE CHAIN MOBILITY OF OFFSHORE SUPPLIERS

For the suppliers there is an almost unlimited possibility to position itself within a value chain depending on the individual strategy, the competences of the company and the market conditions. Some suppliers can furthermore move from one value chain into the other while other suppliers are totally dependent on one value chain. There are two factors which determine whether a supplier can move from one value chain to the other: (1) Position in the value chain, and (2) type of competences.

Third tier suppliers generally have an ability to position themselves in several value chains. Many providers of (general maritime) equipment or services such as pump producers, safety equipment providers, engine manufacturers, pipe producers, shipyards, offshore maintenance etc. have a background in shipbuilding. These companies have usually entered the offshore oil and gas sector and later the offshore wind sector because competition was less fierce in these sectors compared to shipbuilding. Equipment for the oil and gas sector usually demands detailed specifications etc. but

the equipment usually doesn't need to be modified. The difference between providing a pump for a supply vessel in the offshore oil and gas sector and a supply vessel in the offshore wind energy sector is minimal. Equipment for rigs and platforms might need to be adapted, but this is often not an unpassable obstacle.

The second factor is the type of the competences in the company. Some companies have very value chain specific competences, while others have competences that can be applied in several value chains. Among the first are drilling contractors, well management companies, turbine manufacturers etc. These companies are solely dependent on one sector or another. The latter category includes operators of supply vessels or stand-by vessels, freight forwarders, haulage companies etc. These companies possess competences, which can be used in several value chains. This includes (general) maritime competences like navigation and seamanship which can be used in all offshore based sectors or competences in transportation of heavy equipment. It is thus of lesser importance if a truck or a barge moves equipment for a turbine or a rig.

THE THREE IDEAL TYPES OF OFFSHORE SUPPLIERS

Offshore suppliers can position themselves in one or several value chains, in one or several links, at several levels providing different services. At a general level, however, it is possible to identify three ideal types of offshore suppliers:

(1) The specialized offshore supplier, (2) the general maritime or logistics supplier and (3) the third tier supplier.

THREE IDEAL TYPES OF OFFSHORE SUPPLIERS

THE SPECIALIZED OFFSHORE SUPPLIER:

- DIRECT SUPPLIER OR SUB SUPPLIER (1ST TIER OR 2ND TIER)
- VALUE CHAIN SPECIFIC COMPETENCES (ONLY APPLICABLE IN ONE VALUE CHAIN)
- POSITIONED IN FEW LINKS OF THE VALUE CHAIN
- INCLUDE DRILLING CONTRACTORS, WELL MANAGEMENT COMPANIES, MANUFACTURERS OF DRILLING EQUIPMENT, TURBINES ETC.

THE GENERAL MARITIME OR LOGISTICS SUPPLIER:

- OFTEN A DIRECT SUPPLIER OR 2ND TIER SUPPLIER BUT IN SOME CASES ALSO 3RD TIER SUPPLIER
- NON-VALUE CHAIN SPECIFIC COMPETENCES (USUALLY FROM THE SHIPPING SECTOR) WHICH ARE APPLICABLE IN MULTIPLE (MARITIME) VALUE CHAINS
- INCLUDES SUPPLY VESSEL OPERATORS, STAND-BY VESSEL OPERATORS, FREIGHT FORWARDERS, HAULAGE PROVIDERS, SHIPYARDS AND CONSTRUCTION YARDS, PORTS, COMMERCIAL DIVERS, ROV OPERATORS, MAINTENANCE PROVIDERS (E.G. IN STEEL OR ELECTRONICS) ENGINEERS, PROJECT MANAGERS, SHIP MANAGEMENT COMPANIES ETC.

THE GENERAL SUPPLIER:

- TRADITIONALLY 3RD TIER SUPPLIER OF EQUIPMENT (OFTEN FOR SHIPYARDS) BUT INCREASINGLY ALSO DIRECT (1ST TIER) SUPPLIER OF AFTER SALES SERVICES ETC.
- APPLICABLE IN MULTIPLE VALUE CHAINS
- POSITIONED IN SEVERAL LINKS
- VARIOUS LEVELS OF SPECIALIZATION
- INCLUDES MANUFACTURERS OF PUMPS, SAFETY EQUIPMENT, STEEL SECTIONS, TELECOMMUNICATION, PAINT ETC.

The specialized offshore supplier

The specialized suppliers are usually direct supplier or sub suppliers (1st or 2nd tier) to the energy company. The group of specialized suppliers includes drilling contractors (e.g. Transocean or Mærsk Drilling), well management and project management (e.g. Ross Offshore, Schlumberger, Baker Hughes), producers of drilling equipment (e.g. National Oilwell

Varco or WH Wirth) and turbine producers (e.g. Vestas or Siemens Windpower) etc. They provide value chain specific services and have value chain specific competences (and sometimes also value chain specific equipment) which can only be used in one value chain and in many cases only in a few links. They are usually large companies which provide a vital service to the energy company. Their direct link to the energy companies and their dependence on one value chain means that these companies are vulnerable to changes at the macro level (e.g., price on oil, geo politics, energy security and environmental policy), which affect (public) investments in one value chain or the other. It is important to state, that it is the service/activity which is value chain specific and not the company. As a turbine producer Siemens Windpower perform a value chain specific activity, but Siemens also perform a number of other activities in other value chains.

The general maritime or logistics supplier

The general maritime or logistics suppliers are usually direct suppliers or sub suppliers (1st or 2nd tier) to the energy company. This group of suppliers has non-value chain specific competences which can be used in a number of ocean-based industries provided that they have the necessary equipment. These competences include maritime competences (navigation, seamanship etc.), logistics competences (transportation of heavy structures), construction and repair of ships and steel sections etc. Many of these companies have a background in shipping and have entered the offshore industry because of the demand for maritime competences. The group includes operators of supply vessels (e.g. Mærsk Supply Service or World Marine Offshore), stand by vessel operators (e.g. Esvagt), installation vessel operators (e.g. A2Sea), shipyards (e.g. Daewoo Shipbuilding and Marine Engineering or Fjellstrand Shipyard), construction yards and contractors engaged in maintenance of steel structures (e.g. Technip or SEMCO Maritime), divers and ROV operators (e.g. Schilling) and freight forwarders (e.g. Blue Water Shipping) etc. They are usually only engaged in few links but their ability to move from one value chain to the other means that these companies are less dependent on changes at the macro level which affects (public) investments in one value chain or the other.

The third tier supplier

The final category is the third tier supplier. This is by far the largest and most diverse group and includes a broad range of component manufacturers providing, e.g., pumps, safety equipment, steel sections, telecommunication, paint, and engines. These companies have traditionally been suppliers to shipyards and rig construction yards. Many of these companies have, however, begun to provide after-sales services to the energy companies and have thus positioned themselves as 1st tiers (service) suppliers. Many have furthermore begun to provide after sales services to the 1st or 2nd tier suppliers (e.g., drilling contractors, supply vessels operators etc.) and have thus established themselves closer to the end customer even if the manufacturing activities are still positioned far from the energy company. The background suppliers have various levels of specialization but their distance to the energy company means that they are often situated in several links of the value chain and that they can switch from one value chain to the other.

The offshore energy sector is extremely complex, and it is important to state that the categories are ideal types based on the analysis of two value chains. It does, however, give an indication on the most common types of companies in the offshore supply sector.

The value chain model provides an overview of the activities and actors in the offshore energy sector. It furthermore provides a tool for identifying where the individual company is positioned in the value chain(s), what service(s) it provides and in what tier(s) it is positioned. A detailed analysis of various business strategies at the company level can be found in the CBS Maritime report Business Strategies in the Offshore Supply Industry (Roslyng Olesen, 2015).

The value chains for offshore oil and gas and offshore wind are both basically driven by the demand for energy. This is heavily dependent on a number of factors including the price of various energy sources and the policy making of the states which influence legislation, indirect subsidies and direct investments. At the center of both value chains are the energy companies. The energy companies have a number of suppliers and sub suppliers which provide a range of equipment and services to the offshore operations. The supply industry is characterized by horizontal cooperation (between suppliers at the same level) and vertical cooperation (between suppliers in different layers). Finally the suppliers and the energy companies are supported by a number of companies which are usually not considered as part of the offshore sector but are important none the less. These companies provide a number of services including legal advice, financing, insurance etc.

The two value chains have a number of activities in common. Both include (1) a tender and concession phase where the energy company obtains the right to explore and produce energy from the authorities. (2) An exploration phase where the physical location is examined and the installation is planned. (3) An installation phase where the equipment is produced and transported to the site where it is installed. (4) An operation phase where the energy is produced or the energy source is extracted and (5) a decommissioning phase where the field is abandoned.

Most suppliers are positioned in several links of one or both value chains, at various levels (direct supplier, sub supplier, 3rd tier supplier etc.) and providing a variety of services. A supplier can move to new positions within the value chain. The increased servitization is a good example. Traditional manufacturers are often 2nd or 3rd tier suppliers in the installation phase. But by providing after sales services these companies also become direct suppliers to the energy company in the operations phase. Finally a supplier can have different positions in different geographical markets. A supplier can thus be a direct (1st tier) supplier in one market but needs to go through a local contractor (as a 2nd tier supplier) in another market – even if the provided service is exactly the same in both cases.

There are two factors which determine whether a supplier is dependent on one sector or can establish itself in several sectors: (1) Position in the value chain, and (2) general or specialized competences.

Third tier suppliers generally have an ability to position themselves in several sectors. Many providers of equipment or services (pump producers, safety equipment providers, engine manufacturers, pipe producers, shipyards, offshore maintenance etc.) have a background in shipbuilding. These companies have usually entered the offshore oil and gas sector and later the offshore wind sector because competition was less fierce in these sectors compared to shipbuilding. Equipment for the oil and gas sector usually demands detailed specifications etc. but the equipment usually doesn't need to be modified. The difference between providing a pump for a supply vessel in the offshore oil and gas sector and a supply vessel in the offshore wind energy sector is minimal. Equipment for rigs and platforms might need to be adapted, but this is often not an unpassable obstacle.

The second factor is the type of the competences in the company. Some companies have very value chain specific competences while others have competences which can be applied in several value chains. Among the first are drilling contractors, well management companies, turbine manufacturers etc. These companies are solely dependent on one sector or another. The latter category includes operators of supply vessels or stand-by vessels, freight forwarders, haulage companies etc. These companies possess competences which can be used in several value chains. This includes maritime competences like navigation and seamanship which can be used in all offshore based sectors or competences in transportation of heavy equipment which doesn't distinguish if the truck moves equipment for a turbine or a rig.

At a general level there are three ideal types of offshore suppliers: (1) The specialized offshore supplier, (2) the general maritime or logistics supplier and (3) the background supplier.

The specialized suppliers are usually direct supplier or sub suppliers (1st tier or 2nd tier) to the energy company. The group of specialized suppliers includes drilling contractors, well management companies, producers of drilling equipment, turbine producers etc. They have value chain specific competences (and equipment) which can only be used in one value chain and in many cases only in a few links. They are usually large companies which provide a vital service to the energy company. Their direct link to the energy companies and their dependence on one value chain means that these companies are vulnerable changes at the macro level (e.g. price on oil, geo politics, energy security, environmental policy etc.) which affects (public) investments in one value chain or the other.

The general maritime or logistics suppliers are usually also direct suppliers or sub suppliers (1st tier or 2nd tier) to the energy company. This group of suppliers has non-value chain specific competences which can be used in a number of ocean-based industries provided that they have the necessary equipment. These competences are e.g. maritime competences (navigation, seamanship etc.), logistics competences (transportation of heavy structures), construction and repair of ships and steel sections etc. Many of these companies have a background in shipping and have entered the offshore industry because of the demand for maritime competences. The group includes operators of supply vessels, stand by vessels (and in some cases installation vessels), shipyards, construction yards and contractors engaged in maintenance of steel structures, divers and ROV operators, freight forwarders etc. They are usually only engaged in few links but their ability to move from one value chain to the other means that these companies are less dependent on changes at the macro level which affects (public) investments in one value chain or the other.

The final category is the background suppliers. This is far the largest and most diverse group and includes a broad range of component manufacturers providing e.g. pumps, safety equipment, steel sections, telecommunication, paint, engines etc. These companies have traditionally been suppliers to shipyards and rig construction yards. Many of these companies have, however, begun to provide after-sales services to the energy company and have thus positioned themselves as 1st tiers (service) suppliers. Many have furthermore begun to provide after sales services to the 1st tier or 2nd tier suppliers (e.g. drilling contractors, supply vessels operators etc.) and have thus established themselves closer to the end producer even if their main activity (equipment manufacturing) is still positioned far from the energy company. The background suppliers have various levels of specialization but their distance to the energy company means that they are often situated in several links of the value chain and that they can switch from one value chain to the other.

The offshore energy sector is extremely complex, and it is important to state that the categories are ideal types based on the analysis of two value chains. It does, however, give an indication on the most common types of companies in the offshore supply sector.

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CBS MARITIME:
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