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Christiovina Elisabeth</td><td>…………………………………………
(Writer's signature)</td></tr>
<tr><td colspan="2">Faculty supervisor:

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Norwegian Value Creation Related to Development of Offshore Oil and Gas Fields

Master Thesis

By

Christiovina Elisabeth

Supervisor:

Professor
Jonas Odland

Faculty of Engineering and Science
University of Stavanger

Abstract

The development of petroleum field generates substantial values for Norway. In every development project there is always “local” and “global” contentment and Norwegian value creation depends on the combination of the two. Principally, Norwegian value creation is equal to contract value minus the value of imported goods and services for fabrication in Norway and value of Norwegian goods and services used in the fabrication for fabrication outside Norway. In this thesis, Norwegian value creation is defined as a fraction of field development cost that is delivered by Norwegian companies, measured in percentage. Cost estimation is performed using *Acona Cost Estimation Software (ACES)* software which breakdown field development cost into facilities-based costs and activity-based costs.

This thesis estimates and analyzes Norwegian value creation in four different development projects namely Edvard Grieg, Ivar Aasen, Aasta Hansteen, and Gjøa. The four projects are chosen to represent the combination of fixed and floating production platform, dry tree and wet tree (subsea) wells, and local and foreign fabrication of platform. The analysis encompasses analysis of Norwegian value creation in facilities development and well development. Analysis of facilities development comprises 5 main facilities: (1) topside, (2) substructure, (3) subsea system, (4) export pipelines, and (5) power/fiber optic cables, and for every facility 5 main activities are examined: (i) fabrication, (ii) engineering, (iii) procurement, (iv) marine operation, and (v) project management. Analysis of well development covers 2 main activities: drilling service and well completion.

The estimation result shows for facilities development Edvard Grieg generates the largest Norwegian value creation among the four projects estimated at 64% of facilities development cost. Subsequent analysis then shows fabrication and procurement activities of topside account for the biggest development cost in a project. It indicates that location of topside fabrication and origin of goods and services used in topside development have significant effect in increasing Norwegian value creation of a project. For Edvard Grieg case, as both topside and substructure were fabricated in Norway and utilized more Norwegian suppliers in comparison to other projects it generates the highest Norwegian deliveries.

This thesis also aims to analyze the competitiveness of local fabrication (i.e. fabrication in Norway) with respect to Norwegian krone exchange rates to US Dollar (NOK/USD). The analysis reveals that competitiveness of local fabrication increases when Norwegian krone depreciates against US Dollar in a long run. As for well development the four projects have comparable Norwegian value creation in a range 55% - 61% of respective well development cost. The comparable result is achieved because supply arrangements in drilling activities are practically the same between different projects and eventually similar suppliers are utilized

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I would like to deliver my first and foremost gratitude to my supervisor, Prof. Jonas Odland, for the opportunity, advices and directions that he's been given to me during this thesis time. It's been a challenging yet amazing moment to work with him but even so, I can't thank him enough for his guidance and help. Thank you Sir for let me learning precious knowledge through this thesis.

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Last but not least, I would like to say thank you to my friends and University of Stavanger. During the two-years spent with you i truly had incredible time and I am so grateful to meet many great people and experience many wonderful things.

Abbreviations

ACES	Acona Cost Estimating Software
Bcm	Billion Cubic Meter
Bill	Billion
Boe	Billion oil equivalent
CB&I	Chicago Bridge & Iron
E&P	Exploration and Production
EGOP	Edvard Grieg Oil Pipeline
FPSO	Floating Production Storage and Offloading Unit
FSU	Floating Storage Unit
HHI	Hyundai Heavy Industries
LNG	Liquefied Natural Gas
Mill	Million
MPE	Ministry of Petroleum and Energy
NCS	Norwegian Continental Shelf
NOK	Norwegian Kroner
NPD	Norwegian Petroleum Directorate
OCTG	Oil Country Tubular Goods
o.e.	oil equivalent
PDO	Plan for Development and Operation
PIO	Plan for Installation and Operation
PLET	Pipeline End Termination
SHI	Samsung Heavy Industries
Sm^3	Standard Cubic Meter
SMOE	Sembcorp Marine Offshore
SURF	Subsea Umbilical Riser and Flowline
UHGP	Utsira High Gas Pipeline
UK	United Kingdom
USD	United States Dollar

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1. Introduction

Petroleum industry has been the key part of Norway's economy for the last 50 years. Offshore oil and gas activities in Norwegian Continental Shelf (NCS) are currently the largest economy sector that creates significant value added and revenues to the country (Norwegian Petroleum Directorate, 2014). Since production started on NCS in the early 1970s, oil and gas sector has contributed more than NOK 11,000 billion to Norway's Gross Domestic Product (GDP) (Norwegian Petroleum, 2015) and today is accounted about 20% of Norway's annual revenue and nearly 40% of country's annual export (Statistics Norway, 2015). Although the staggering figures is deteriorating on the account of lower oil price petroleum industry is still credited as the most important sector in Norway (Norwegian Petroleum, 2015).

As one of the largest and most expensive industries, the oil and gas industry creates long and complex value chain activities to bring petroleum products from reservoir to market. One of the activities is petroleum field development. Ever since oil and gas was found at Norwegian Continental Shelf (NCS) in 1969, more than 100 field development projects have been carried out (Norwegian Petroleum Directorate, 2016). Every single project demonstrates distinctive development solution and strategy to ensure profitability and safety. Based on this development solution, project execution strategy and procurement strategy are developed. These strategies determine how the project will be executed and how the contracts (EPC contracts and others) will be defined, awarded and followed up.

Project execution and procurement strategies define the combination of “local” and “global” content in specific development project. When the goods and services used in development projects come from Norwegian businesses it will generate substantial values to local society in the forms of employment and state revenues. Since different development solutions lead to different procurement strategies, it is valuable to study the Norwegian value creation in several different projects and pinpoint the differences between individual projects. The study also aims to identify specific element of the project that has the biggest influence in increasing Norwegian value creation.

Development solution for the new field in NCS is basically divided into development with stand-alone installation or subsea tied-back to existing installation (i.e. satellite project). Stand-alone facilities can be a fixed or floating platform equipped with dry-tree or wet-tree wells while satellite project requires modification of existing host platform to facilitate the tie-back. In satellite development, project's cost varies from case to case but delivery by Norwegian companies is similarly high for every case as subsea technology is a strong Norwegian ownership. On the contrary stand-alone project has more combination of local and global content and Norwegian value creation is pretty varied from one project to another. For that reason and to serve the purpose of the study this thesis focuses on evaluation of stand-alone projects with new platform development.

Four different development projects with stand-alone installation are analyzed. They are Edvard Grieg, Ivar Aasen, Aasta Hansteen and Gjøa. The four projects represent different stand-alone concepts and procurement strategies where combination of fixed and floating production platforms, dry tree and wet tree (subsea) wells, and local and foreign fabrication of the platform are chosen. The scope of study consists of analysis of project's activities and examination of project's suppliers. Activity in analysis comprises facilities development and drilling & well completion while supplier in analysis encompasses main contractors and first subcontractors. In corresponding to evaluation of project's suppliers a particular discussion about competitiveness of local fabrication (i.e. fabrication in Norway) with respect to krone currency exchanges is carried out.

Information and data used in the study are obtained through miscellaneous secondary data. As it is particularly challenging to find academic journals with specific topic of Norwegian value creation, the secondary information used in the study mainly comes from companies' presentations, government publications, and special reports from research institutions and consultants. A limited and incomplete scope of value creation and employment is also expected from this thesis for the source of information is solely a secondary data.

This thesis is divided into 4 main parts: Part 1: Introduction defines the background, objectives, and scope of analysis of the thesis; Part 2: Theory contains descriptions of Norwegian oil and gas industry value chain and methodology to estimate the Norwegian value creation; Part 3: Results presents the development overview of individual project, result estimation of Norwegian value added in every project, and assessment of the result; Part 4: Discussion contains discussion to answer thesis's objectives, and Part 5: Conclusion presents the conclusion of this thesis.

2 Theory

2.1 Norwegian Petroleum Industry Overview

2.1.1 History, Reserves, Production, Export Overview

The discovery of gas in Groningen, The Netherland, on 1959 led Philips Petroleum to apply for permission to explore Norwegian part of the North Sea in 1962. In 1969, the first oil was found and in 1971 the first production started at Ekofisk field. The following years saw the boom of oil era with several major discoveries such as Statfjord (1974), Gullfaks (1978), Oseberg (1979), and Troll (1983) were made. After 40 years oil and gas sector had achieved several important milestones and has significantly transformed Norway's economy as can be seen in Figure 1.

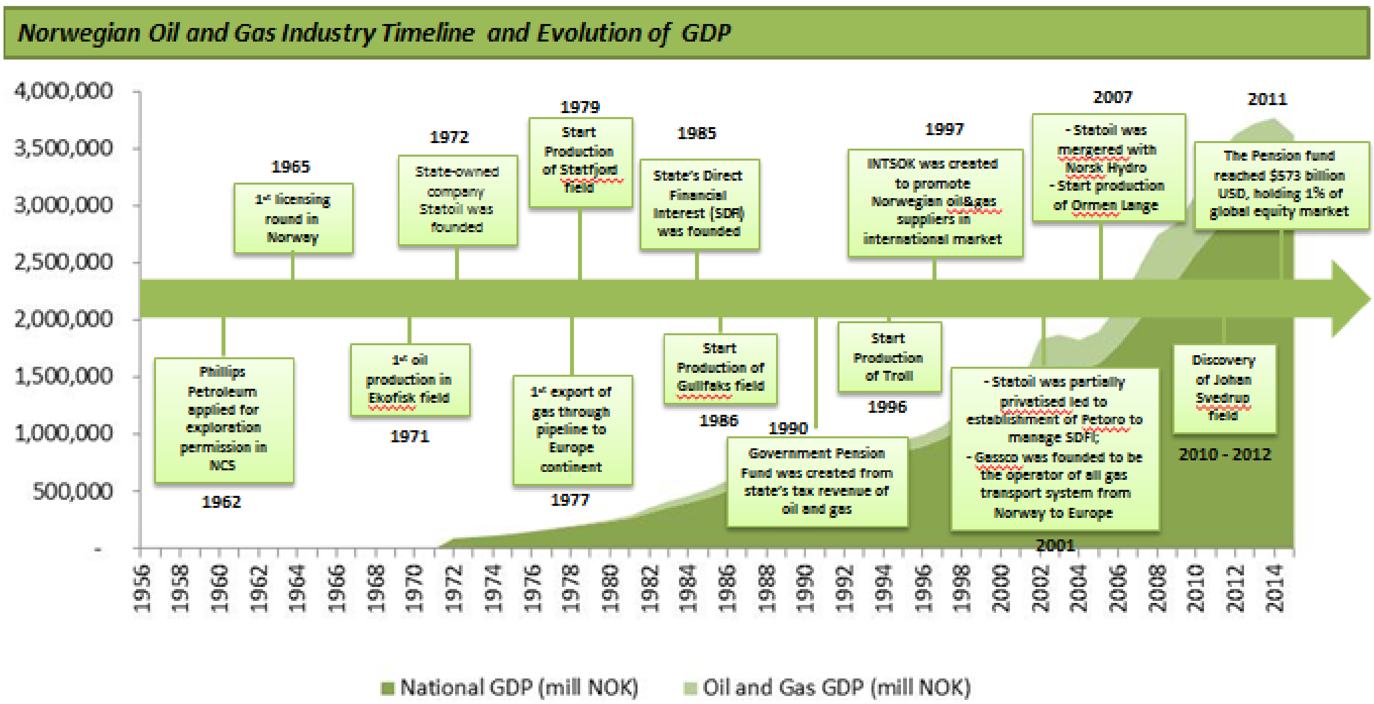


Figure 1 Norwegian oil and gas industry timeline and evolution of national GDP (Leskinen, et al., 2012; Norwegian Petroleum Directorate, 2014)

Norwegian oil and gas is situated in an area called Norwegian Continental Shelf (NCS) (Norwegian Petroleum Directorate, 2014). The NCS has a total area of 2,039,951 square kilometers and divided into 3 main ocean areas: North Sea (142,000 km^2), Norwegian Sea (287,000 km^2), and Barents Sea (772,000 km^2). Hydrocarbon production is concentrated in North Sea which has 60 producing fields and followed by Norwegian Sea (16 fields) and Barent Sea (1 field). In total, NCS produces about 6 billion Sm^3 o.e. of oil and gas from 1971 to 2014 with oil accounts for 63% of this number (Norwegian Petroleum Directorate, 2015).

Production of oil was particularly strong in 1985-1995 when a number of largest fields were brought on stream and peaked in 2001 at 3.4 million barrels/day before constantly declined until 2013 (BP, 2015). In 2014 the production bounced back and expected to soar when Johan

Svedrup, the newest major discovery, comes on stream in 2019. Contrast to oil, gas output has risen since 1993 and likely to remain high amid the development of several big gas fields such as Aasta Hansteen and Martin Linge (BP, 2015). Figure 2 shows the history and estimation of future production of liquid and natural gas in NCS.

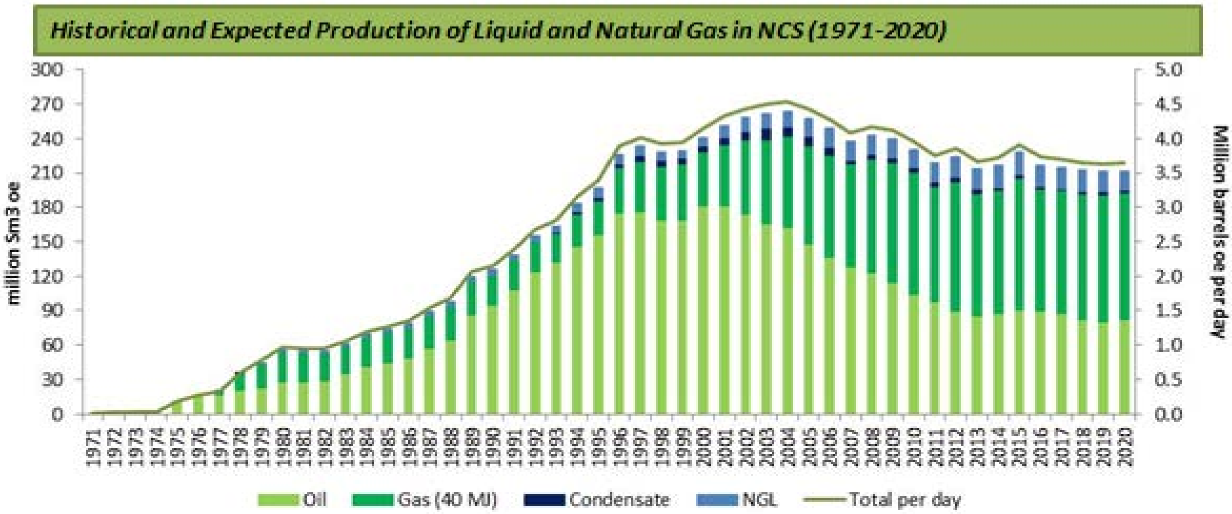


Figure 2 Historical and expected production of liquid and natural gas in NCS from 1971 to 2020 (Norwegian Petroleum Directorate, 2016)

In 2015 gas production reached 115 billion Sm^3 and oil output was 91 million Sm^3. Norwegian oil and gas reserves are the 21st and 16th largest in the world with proven reserves at 6.5 billion barrels of oil and 1.9 trillion m^3 of gas at the end of 2014 (BP, 2015). A number of Exploration and Production (E&P) companies serves as operators for both development and production stages in NCS. Norwegian state company, Statoil, and major international companies dominated the competition up to 2000 but increasing number of medium-sized companies and European gas/power companies have grown since then.

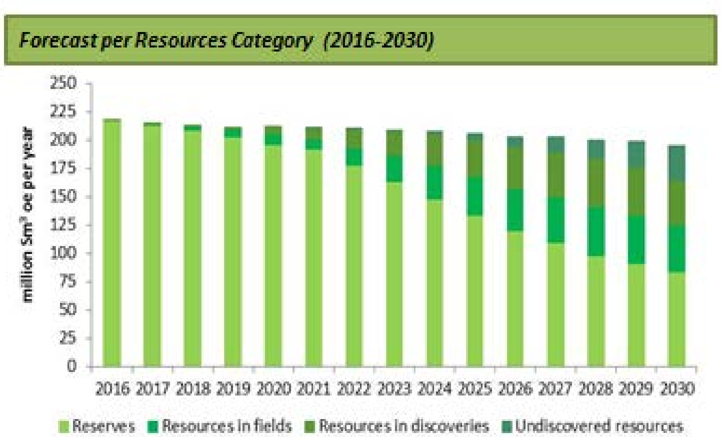


Figure 3 Forecast of volume hydrocarbon per resource category (Norwegian Petroleum Directorate, 2016)

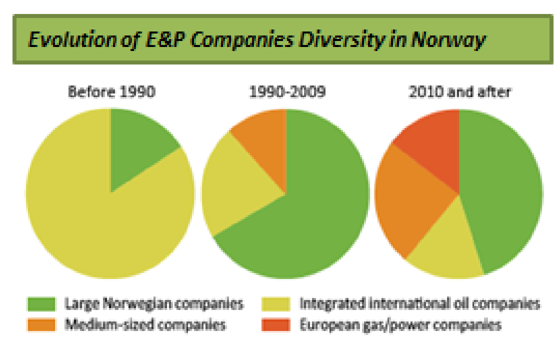


Figure 4 Evolution of E&P companies diversity (Norwegian Petroleum Directorate, 2015)

Almost all of oil and gas produced from NCS is exported. Norway is the world's 8th largest exporter of crude oil with total export about 75 million Sm^3 in 2015 and 3rd largest exporter of natural gas with total export 114 billion Sm^3 (Norwegian Petroleum, 2016). Oil and gas is exported directly from the field or from onshore terminal to the markets (Norwegian Petroleum, 2016). Delivery from the field uses shuttle tanker or pipeline and normally for closer destinations while delivery from onshore terminals uses larger tankers and for farther destinations. There are 4 onshore terminals to refine oil from NCS: Sture, Mongstad, and Karstø in Norway and Teeside in Britain. Norwegian crude oil is mostly exported to Germany, United Kingdom (UK), France, The Netherlands, Belgium and Sweden while other destinations include Mediterranean, Asia, and America.

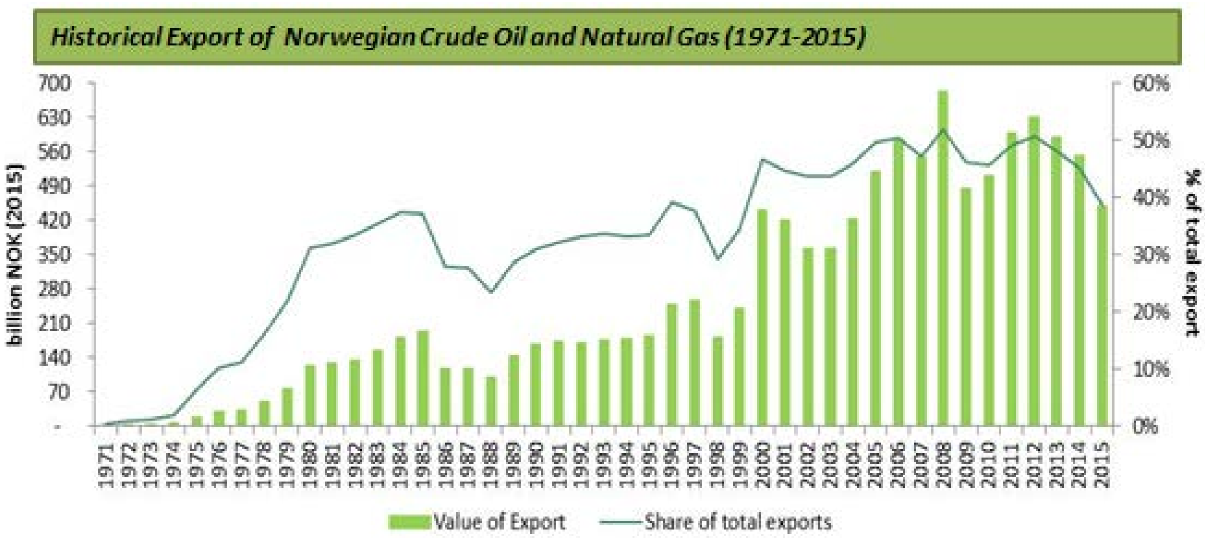


Figure 5 Historical export value of Norwegiancrude oil and natural gas from 1971 to 2015 (Statistics Norway, 2016)

Norway supplies more than 20% of European Union gas consumptions (Norwegian Petroleum, 2016). The gas is mostly sold to Germany, UK, France, and Benelux (Belgium, The Netherlands, and Luxembourg). In these countries supply gas from NCS is very important as it accounts for about 20% - 40% of domestic gas demand. Almost all of Norwegian gas is exported through pipelines. Norway builds a very integrated gas pipeline network with total length approximately 8300 km. The pipelines transport rich gas from offshore platforms to gas receiving terminals in key markets. In addition to pipelines, Norway also export a small amount of gas in a form of LNG (Liquified Natural Gas) with LNG carriers. At present only gas from Snøhvit field in Barent Sea that is converted to LNG on a large scale.

2.1.2 Norwegian Petroleum Activities

Norwegian petroleum activities is described in Figure 6. Petroleum industry in Norway is governed by regulatory framework called Petroleum Act (Norwegian Petroleum Directorate, 2014). Under Petroleum Act petroleum activities is carried out through licensing agreements or concessionary systems and production licenses are awarded through licensing rounds (Norwegian Petroleum Directorate, 2014; Odland, 2014). Here, Ministry of Petroleum (MPE) based on the recommendation of Norwegian Petroleum Directorate (NPD) and approval from Norwegian parliament (Storting) announces certain blocks that are considered ready for further exploration to all E&P companies. Companies may apply for the chosen block individually or in groups and MPE will put together a group of licensees, normally consists of three to five companies, and select the operator for development and production phase. Operator for development and production phase is usually the same but different operators can be chosen for some considerations.

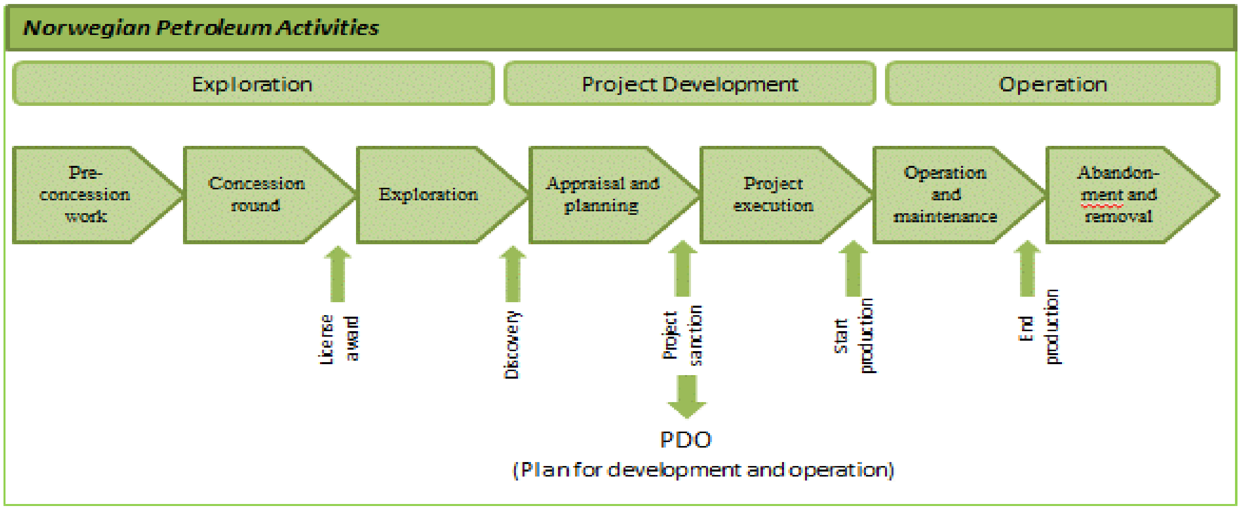


Figure 6 Norwegian Oil and Gas Business Model (Odland, 2014)

The production license is valid for a certain number of years and govern all obligations and rights of licensees in relation to Norwegian state. During the licensing period, exploration drilling and other geological/geophysical works must be carried out. Once the license's partnership decided to develop a field they are required to submit a Plan for Development and Operation (PDO) and Plan for Installation and Operation (PIO) to MPE (Odland, 2014). PDO contains a detail development solution of the field including areas of geology, geophysics, reservoir engineering, facilities (platform design, transportation, abandonment plan, and economic assessments. PIO describes facilities for transport and utilization of petroleum in more specific way than PDO. Along with the PDO and PIO submission, impact assessment is also submitted to relevant stakeholders. Impact assessment explain the impact of development project to environment, fishing activities, and society and what would be the proposed safety measurement.

In parallel with PDO submission, project partnership represented by development operator, awards different major contracts to various contractors. The contracts consist of EPC(I) contracts of facilities development, contracts of production drilling, and contracts for logistic and transportation. In most cases contractors selection is performed through tender system (Agenda Kaupang, 2015). Here, a short-list of contractors is invited to submit procurement proposal and project's partnership will select the winning contractors based on specific criteria such as price, quality, safety record, and technical capability. Procurement of goods and services for every major contract depends on E&P companies' contract strategy (Agenda Kaupang, 2015). Some companies nominate a number of suppliers and let EPC(I) contractors hold the tender between nominated suppliers and select the winner. Other companies choose their own suppliers and directly deliver the goods and services to contractors. Another companies give contractors the authority to select the suppliers but exert siginificant influences in making final decision. This strategy is possible because major contractors normally have their own suppliers lists as well.

The conractors and suppliers in development phase consist of Norwegian and international companies. To be considered as qualified they must adhere to regulations and standards set by Norwegian authorities and industry players. NORSOK and DNV are those two most important and stringent standards. Credited to better understanding of industy's best practices, more access to site, and supports from Norwegian authorities, many Norwegian suppliers have delivered excellent performance in following the standard and eventually become more competitive than international competitors. Once all the major and other contracts had been awarded, operator and partners continue the development project with performing production drilling. Each operator has its own drilling strategy but in most cases production drilling is only started when large portion of the facilities have been ready in order to optimize the drilling cost. Production drilling will normally continue until after commercial production in the field commenced.

In total, facilities development can take up to several years depending on the type of development solutions (Norwegian Petroleum Directorate, 2015). For development solution with stand-alone platform (fixed or floating platform), the development period is longer than subsea tie-back or satellite installation and depends on the platform's design and technical requirement. Here, the capacity and competence of platform's yards is very important to ensure on-schedule delivery with proper quality. When facilities development completes, production operator takes over the responsibility to run day-to-day operations of the field and performs regular maintenances. In certain cases there could be situations where platform needs to be modified to facilitate a new project, for example subsea tie-back project. In this case, platform's modification becomes the responsibility of existing host-operator but the cost is a part of new project's capital investment.

Every petroleum field experiences different operating life. Operating life of a field is usually mentioned in the PDO together with the recovery method for the reservoir. In addition to the original recovery method, operator also carries out different production iniatives to improve well recovery and extend field's operating life. Once the field is no longer economical, operator will shut down the production and performs well abandonment and facilities removal. Prior to abandonment and removal, however, operator and partners are required to apply for authorities approval.

2.2 The Oil and Gas Industry Value Chain in Norway

2.2.1 Oil and Gas Industry Value Chain and Value Creation in Norway

The term value chain was firstly introduced by Michael Porter in 1985 through his book "Competitive Advantage: Creating and Sustaining Superior Performance (The Economist, 2009). It systematically examines all activities performed within a firm and how they interact to be a source of competitive advantage and create values for company. Porter distinguishes the activities into primary activities and support activities. Primary activities are directly related to production and delivery of product or service and supporting activities help to improve effectiveness and efficiency of primary activities. For petroleum sector industry's value chain in general comprises of activities that include field development, production, processing, transportation and marketing of hydrocarbon. Figure 7 depicts the general oil and gas industry value chain and Figure 8 illustrates the value chain for Norwegian oil and gas industry.

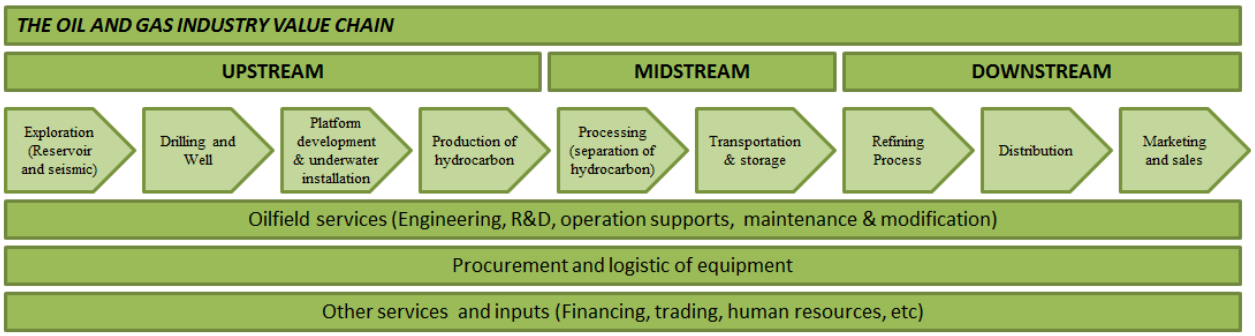


Figure 7 The oil and gas industry value chain (Leskinen, et al., 2012)

Primary activities in petroleum value chain are divided into 3 main sectors: upstream, midstream, and downstream. Value creation activities start with hydrocarbon exploration. If the initial exploration succeeds field development project is carried out and followed by commercial production. These activities are generally called exploration & production (E&P) or upstream oil and gas. Once produced, hydrocarbon is processed and transported to refinery and/or gas terminal for final processing before marketed and distributed to customers. Processing and transportation are referred to midstream oil and gas while refinery, marketing, and distribution are known as downstream. Different kind of oilfield services, equipment procurement, and other related services act as supporting components and inseparable from primary activities.

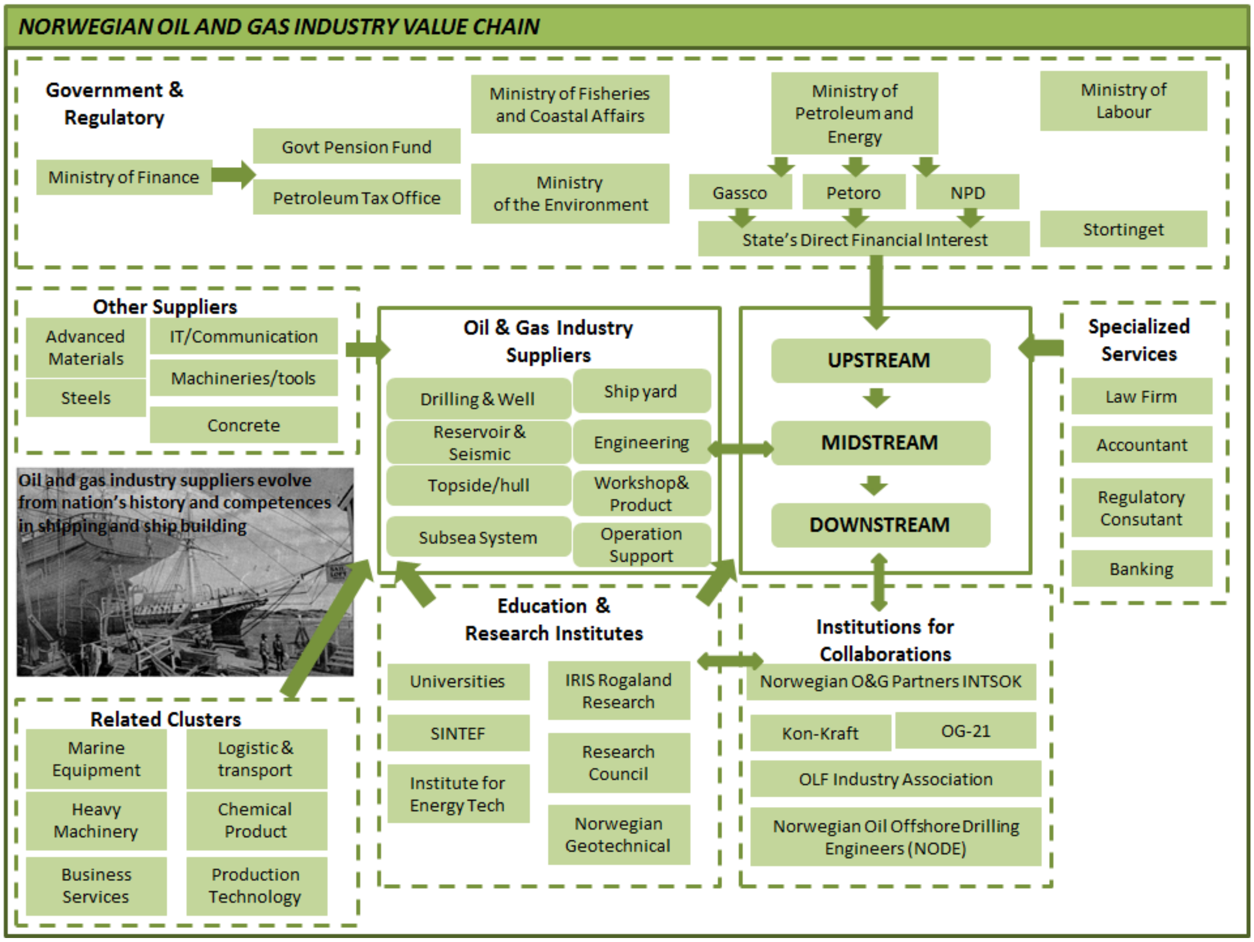


Figure 8 Norwegian Oil and Gas Industry Value Chain (Leskinen, et al., 2012)

In Norway, there are organizations to perform primary and supporting activities throughout the whole value chain. Most of the organizations are concentrated in upstream and midstream sector as downstream has the smaller market size. Upstream sector comprises of E&P companies who are the operators or partners of the production licenses, oilfield services companies who produces goods and services used in E&P activities, and other public or private organizations. The companies vary in sizes and consisting of Norwegian-owned companies and Norwegian subsidiaries of International Companies. As of 2015, around 54 E&P companies and more than 1250 service companies are registered in Norway (Norwegian Petroleum, 2016).

As a part of global economy Norwegian companies collaborate and compete with international firms in both local and global competition. In Norway, collaboration and competition with foreign companies are particularly high in development phase. For each specific development project there is always a combination of "local" and "global" content. The Norwegian value creation depends on this combination. The Norwegian value creation occurs if activity performed in the project is delivered by Norwegian companies or completed using Norwegian goods and services. Correspondingly, Norwegian value creation is equivalent to the contract value minus the value of imported goods and services for fabrication in Norway and equivalent to the value of

Norwegian goods and services used in the fabrication for fabrication outside Norway (Agenda Kaupang, 2015). In national perspective value added is often referred to as Gross Domestic Product (GDP) or Gross National Product (GNP) which measure the monetary value of goods and services produced by Norwegian-owned and Norwegian subsidiaries firms within a certain period of time (International Monetary Fund, 2013).

2.2.2 Oil and Gas Supplier Cluster in Norway

Oilfield services companies in Norway can be classified into 8 main clusters: (1) drilling and well; (2) geology and seismic; (3) platform (topside and hull); (4) subsea system; (5) shipyards; (6) Engineering services; and (7) Workshops & product suppliers; and (8) operational support (Leskinen, et al., 2012; Ernst & Young, 2016). Table 1 presents brief descriptions about individual cluster. The clusters are not centralized in one place but represented throughout the country. Stavanger city represents the widest ranges of goods and services that come from different clusters. In and around Oslo there are clusters of reservoir and seismic companies as well as engineering consultants. Trondheim has a strong research and development activities and many service firms and operators put their research facilities there. Bergen is a center for platform maintenance and subsea equipment clusters. Kongsberg in Buskerud has a strong cluster of subsea technology, automation, and dynamic position companies. Southern Norway is the center of drilling & well cluster and Ålesund is a home for shipbuilding and outfitting activities (Norwegian Petroleum, 2016).

Table 1 Upstream oil and gas suppliers clusters (Leskinen, et al., 2012; Ernst & Young, 2016)

Supplier Cluster	Description	Norwegian-owned Companies	Norwegian Subsidiaries of Foreign Companies	Estimate number of companies (2014)
Drilling and Well	Consisting of companies that owned and/or operate the drilling; companies that provide well services; companies that supply equipment and system for drilling & well services.	Odfjell Drilling, BW Offshore, Fred Olsen Energy	Seadrill, Maersk Drilling, Transocean, Schlumberger, Halliburton, Baker Hughes	198
Reservoir and seismic	Consisting of companies that operate seismic vessel to acquire data; companies that process, analyze, and interpret the data; companies that supply equipment for data acquisition and analysis	TGS, Bergen Oilfield Services, Electromagnetic Geoservices	BGP, Roxar , Fugro	51
Platform (Topside/hull)	Consisting of companies that provide EPCI of topside/hull; companies that provide maintenance & modification of topside/hull	Aker Solutions, Kvaerner, Sevan Marine	Aibel, Westcon, Rosenberg Worleyparson	270
Subsea system	Consisting of companies that engineer and fabricate subsea equipment (subsea production system and subsea umbilical, riser, and flowline (SURF)) and provide inspection, maintenance and repair services	Aker Subsea, DOF Subsea	FMC Tech, Technip, Subsea 7, GE Oil & Gas	96
Shipyard/ship	Consisting of companies that build	Vard Group,	STX Europe	41

building	different kind of offshore vessels such as platform supply vessel (PSV), anchor handling tug supply vessel (AHTS) and offshore subsea construction vessel (OSCV)	Kleven Verft, Ulstein; Simek AS		
Engineering service	Consisting of companies that provide skilled personnel (engineers & consultants) to operators & suppliers	DNV, Aker Engineering, Frontica	Wood Group, CB&I	N/A
Workshop & product	Consisting of companies who design, develop, fabricate product & system to offshore installation, rig, and vessel	Kongsberg Maritime AS, Bergen Engines AS	Wartsila, Rolls-Royce,	N/A
Operation support	Consisting of companies that support E&P operators in production phase (providing services like offshore logistics & helicopter services, modification & maintenance, and production equipment and services)	IKM Testing AS, Aker Solutions Mmo AS, Beerenberg, Apply	Bilfinger, Kaefer, ESS Support Service, ASCO, ESCO	289

2.2.3 Success Factors of Norwegian Oil and Gas Industry Suppliers

Unlike most oil and gas producing nations, Norway has a remarkable performance in developing national cluster of suppliers that deliver product and services to E&P companies (Leskinen, et al., 2012). There are two important factors behind this success. First, difficult geographical setting of NCS and strict regulatory requirements led to various innovations in oil and gas technology by operators and suppliers. The Norwegian Continental Shelf is particularly regarded as advanced offshore laboratory that has successfully develops innovations such as subsea technology, enhanced oil recovery methods, and CO2 reduction system. Second, government interference through effective policies that enhance competencies of related industries including pre-existing shipping and mining has contributed to develop and protect competitiveness of Norwegian suppliers (Leskinen, et al., 2012).

A very first policy was a Royal decree in 1972 that emphasized utilization of Norwegian suppliers to foreign suppliers if the earlier were more competitive in price, service and quality deliveries. As a part of licensing process, foreign E&P companies who want to do operation in NCS were also required to come up with plans of developing local suppliers' competences. As a return Norwegian authorities will subsidize field development costs through tax deduction (Leskinen, et al., 2012). A so-called "Goodwill agreements" was also introduced as one of criteria for concession assignment. Here, foreign E&P companies were obliged to support as much as possible Norwegian R&D by conducting the activity in Norway. It is estimated about 80% of Norwegian R&D had been funded by this program. When Norway entered a free trade agreement with European Union in 1994, all those "protection policies" were forced to be deregulated and equal opportunities are given to both local and EU suppliers.

2.2.4 Norwegian Suppliers: World Leaders of Subsea Technology

Out of the entire cluster, subsea system is a particular cluster that has a unique and strong position for Norway. A geographical setting of NCS and an effort to establish less-complicated and cost-effective solutions are the main reasons for Norway to develop its subsea technology to the next level. The new discoveries that previously deemed as “impossible” or “inefficient” to exploit due to increasing depth and distances from land or uneconomical field development cost, compared to the hydrocarbon reserves, when the field is developed with stand-alone facilities are now more feasible to exploit using subsea installation. In fact development with subsea system has become the major solution at NCS for the past few years as smaller fields are dominated portfolio of new discoveries (Norwegian Petroleum Directorate, 2015). These days, application of subsea system is not only practical for development of new fields but also useful for operation of existing fields particularly in an effort to increase recovery rates.

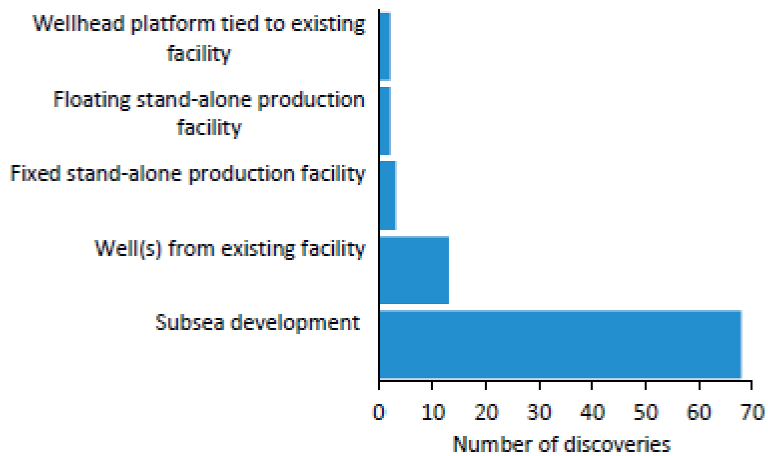


Figure 9 Development solutions for discoveries from 1999-2013 (Norwegian Petroleum Directorate, 2015)

Led by Statoil, development of subsea technology in NCS has gone through several important milestones and successful breakthroughs (Norwegian Petroleum, 2016; Statoil, 2016; Underwater Technology Foundation, 2016). The earliest generation of subsea development in Norway was begun with a very first subsea project at Frigg field in 1982. Then in 1986 a first ever operated subsea well was developed by Statoil for Gullfaks field. Afterwards, a first subsea template was installed for Tommeliten field in 1988. For a next decade (1990s-early 2000) a more cost-effective subsea concept was developed to accommodate smaller discoveries near existing offshore facilities. Known as subsea satellites this technology was successfully implemented around Sleipner, Statfjord, and Heidrun production platforms.

In late 1990s when E&P activities started to go deeper and further from land, the then generation of subsea technology had enabled floating production system to be deployed in deeper water of NCS. Åsgard and Troll fields are among the fields that came on stream during this time. In the same period the idea of subsea factory was established and two important steps were made. The first step was using pump to lift the oil from the sea bed to production vessel and second step was re-injection (to reservoir) of produced water that was removed from the well stream on the sea bed. Then, between 2004 and 2007 the next generation of subsea technology enabled fields with extreme reservoir pressure and temperature such as Kristin and very far transportation distance such as Ormen Lange and Snøhvit to be successfully developed. This period also witnessed another milestone for subsea factory ambition where subsea separation, boosting, and injection technologies were installed in Tordis field.

Compared to dry-tree well subsea well is argued to have far lower recovery rate since well intervention is more challenging to do. However, when “smart well” technology was invented in 2007 operator was enabled to gather more reservoir data and together with subsea suppliers developed a new subsea equipment to perform more-efficient well intervention and eliminate the gap from platform-completed well. Today, the newest breakthrough in subsea technology is a subsea compression system that is aimed to maintain production level as the pressure in reservoir drops. The world’s first subsea compressor was prepared for Åsgard field while the first subsea wet gas compressor was prepared for Gullfaks. Implementation of the two compression system is argued to effectively increase recovery rate of both fields by 306 and 22 million boe respectively.

Continuous innovation of subsea technology in Norwegian Continental Shelf is mainly pioneered by Statoil in cooperation with Norwegian subsea contractors, research institutes, and academia. The R&D activities are performed in Norway and pilot components are normally built and tested locally (Norwegian Petroleum, 2016). Examples come from Åsgard and Gullfaks subsea compressors delivered by Aker Solutions and OneSubsea that were entirely designed, fabricated, and tested in Western Norway. Upon successful implementations in NCS Statoil started introducing Norwegian subsea technology to the rest of the world. As early as late 1990s Statoil installed the same technology for their operated field in West Africa and Lufeng (China). Since then several International E&P companies started taking interest in these solutions and eventually bring the technology out to other continental shelves (Statoil, 2014).

2.2.5 Oil and Gas Supplier Cluster Performance

Over the past years oil and gas suppliers in Norway have experienced a remarkable growth (Leskinen, et al., 2012; Ernst & Young, 2016; Norwegian Petroleum, 2016). Though recent oil prices slump hit the industry negatively, service industry in Norway is still country’s second-largest industry in terms of turnover after E&P sector. In the past 5 years industry’s revenue had grown from NOK 350 billion in 2010 to NOK 527 billion in 2014 (see Figure 10). Revenue from international market grew significantly from NOK 50 billion in 2000 to NOK 195 bill in 2014. Employment in the industry also grew from 59,000 in 1990 to more than 115,000 in 2015. At the end of 2015 more than 1250 firms are registered in Norway with small-medium enterprises that generate annual revenue less than 1 billion NOK dominate the competition (Norwegian Petroleum, 2016; Ernst & Young, 2016).

Among supplier clusters drilling and well consistently generated largest annual revenues from 2010 to 2014 with average NOK 125 bill/year. It was subsequently followed by workshop & product (NOK 79 bill/year), operation support (NOK 69 bill/year), subsea system (NOK 62 bill/year), platform (NOK 29 bill/year), Reservoir & seismic (NOK 27 bill/year), engineering services (NOK 26 bill/year), and ship building (NOK 17 bill/year) (Ernst & Young, 2016). For international sales, topside and processing equipment, subsea system, and ship building (mainly offshore service vessel) are the three clusters that make up the largest international turnover for Norway (Norwegian Petroleum, 2016). In terms of market coverage, Norway-based suppliers present in more than 80 countries and cover integrated supply chain activities from procurement/logistic to fabrication, sales, installation and engineering activities (see Figure 11). South Korea is the biggest destination market with approx. NOK 38 bill deliveries in 2014 followed by UK (NOK 27 bill), Brazil (NOK 26 bill), USA (NOK 12 bill), and Australia and China (NOK 11 bill).

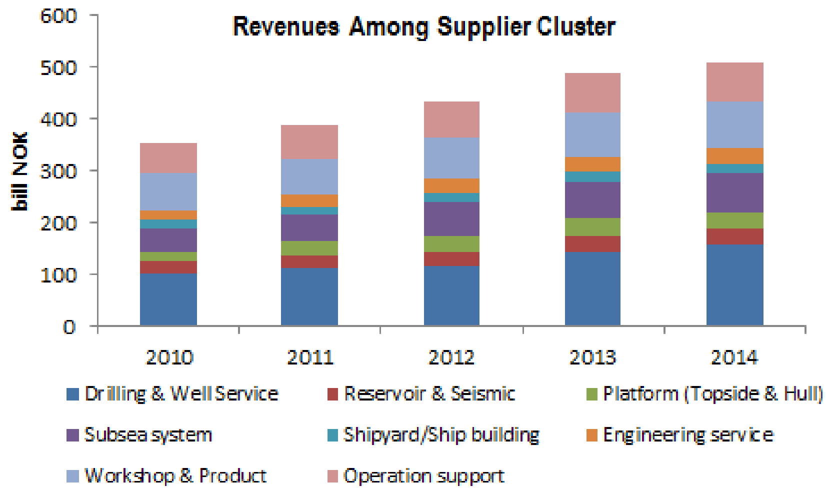


Figure 10 Norway-based suppliers revenues in 2010-2014 (Ernst & Young, 2016)

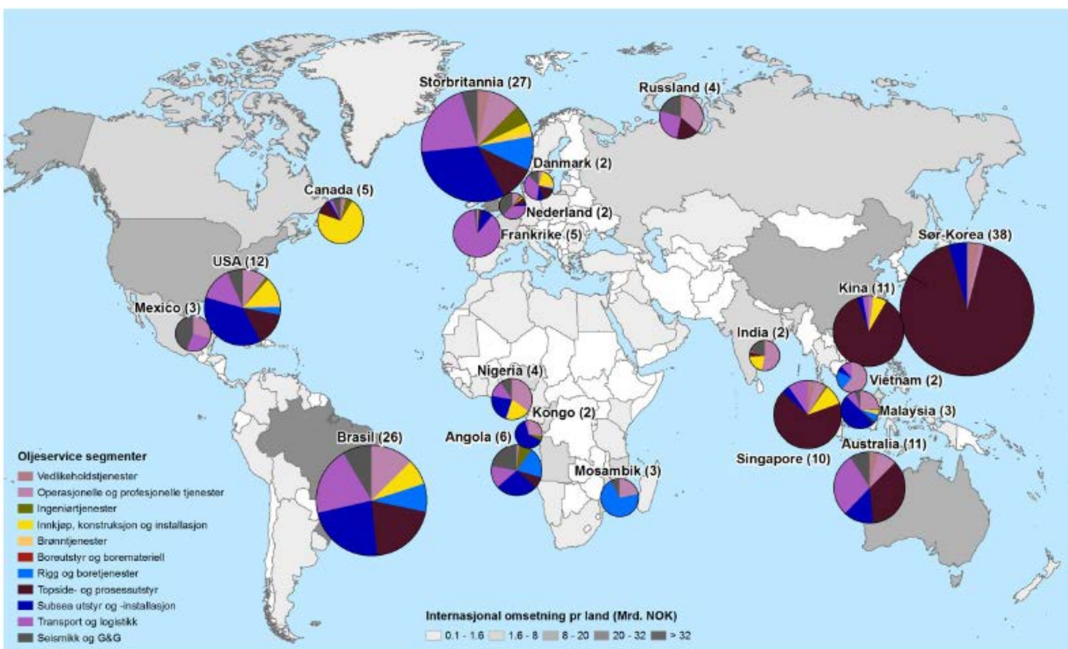


Figure 11 Norway-based suppliers market coverage in 2014 (Adopted from Rystad Energy, 2015 through Regjeringen, 2016)

2.3 Norwegian Value Creation Estimation Methodology

In this thesis, Norwegian value creation is defined as a fraction of field development cost that is delivered by Norwegian companies, measured in percentage. Cost estimation is performed using *Acona Cost Estimation Software (ACES)* software which breakdown field development cost into facilities-based costs and activity-based costs as described respectively in Figure 12 and 13. The facilities-based costs consist of 5 main sub-costs: topside cost, substructure cost, subsea system cost, pipelines cost, and power/fiber optic cables cost. For each facility cost, activities-based cost is defined. Activities-based costs consist of engineering cost, procurement cost, fabrication/assembly cost, marine operation cost (including transportation, offshore commissioning, tow-out, and hook-up operation), and project management cost. In addition to these costs, activities-based cost also encompasses drilling cost and well completion cost.

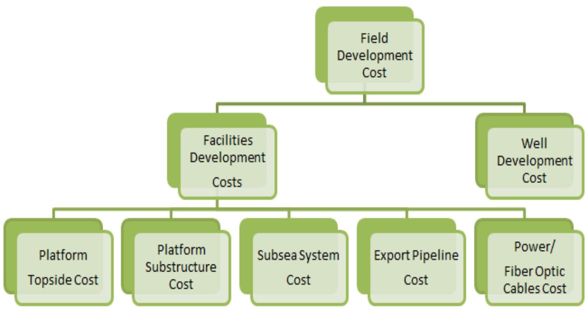


Figure 12 Facilities-based costs breakdown structure

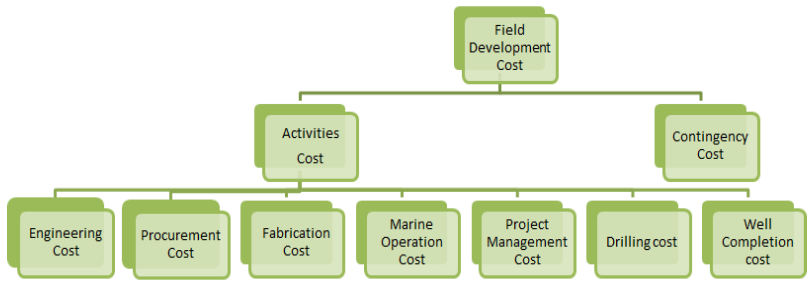


Figure 13 Activities-based costs breakdown structure

Figure 14 describes the methodology to estimate the Norwegian deliveries in facilities development for each individual project.

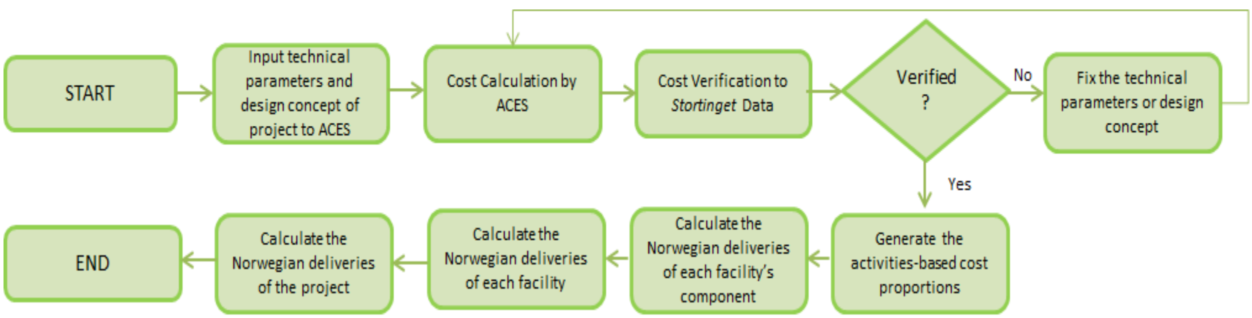


Figure 14 Norwegian value creation estimation method

Cost calculation by ACES requires users to input technical parameters and design concept of each field development. Once inputted, facilities and activities-based costs were calculated. Appendix A presents the general formula used in cost calculation and Figure 15 illustrates the result of ACES calculation. The overall calculation result is presented in Appendix B. Cost verification was performed afterwards to validate the result. Verification was performed by comparing the total development cost calculated by ACES to *Stortinget* data[1]. Calculated cost is deemed as valid if variation to *Stortinget* data is within 10%. Verification result as presented in Appendix C shows that the ACES's calculated costs for the four development projects are valid.

[1] Every year, *Stortinget* publishes the new estimate of investment budgets for every incomplete development. projects. This thesis uses *Stortinget* data St.prp. Nr. 1-2016 for the cost verification purpose.

Once verified, activities-based cost proportions of each facility were generated to estimate the Norwegian deliveries in every project. Decision rule in Table 2 is used as a basis of estimation and is relevant for each specific component of the facility. At the same time, suppliers of the component were identified and other information related to the activity was pinpointed. Appendix D presents the detail of cost proportions for the four projects.

CAPEX FACILITIES OVERVIEW										**mill.NOK**
Cost element	Engineering	Procurement	Construction	SUM EPC	Marine op	SUM EPCI	Management	Base estimate	Contingency	Total
Topsides	3170	4448	4116	11734	88	11822	1655	13477	2022	15498
Substructure incl conductors/risers	291	488	531	1310	315	1624	227	1852	278	2130
Piles, anchors and mooring lines	0	196	0	196	316	512	72	583	87	671
Sum Platform	*3461*	*5131*	*4647*	*13239*	*718*	*13958*	*1954*	*15912*	*2387*	*18298*
Subsea/WHP production equipment	0	0	0	0	0	0	0	0	0	0
Flowlines and spools	9	25	0	35	88	122	17	139	21	160
Structures (RB, PLET, PLEM, T, Y)	54	152	0	207	119	326	46	372	56	428
Risers for flowlines/pipelines	75	15	16	107	98	205	29	234	35	269
Umbilicals with risers	0	0	0	0	0	0	0	0	0	0
Sum Subsea	*139*	*193*	*16*	*348*	*305*	*654*	*91*	*745*	*112*	*857*
Export pipelines	42	553	144	740	1158	1898	266	2163	433	2596
Power cables wih risers	0	0	0	0	0	0	0	0	0	0
SUM Facilities	*3642*	*5878*	*4807*	*14327*	*2182*	*16509*	*2311*	*18820*	*2931*	*21751*

CAPEX WELLS OVERVIEW	**days per well**	**days**	**mill.NOK**
Drilling	*34*	510	2608
Completion	*20*	305	1714
Drilling and completion	*54*	815	4322

Figure 15 Illustration of cost calculation result using ACES ACONA.

Table 2 Decision rules used in estimating Norwegian value creation (component level)

Activity	**Decision Rule**
Fabrication	- If fabrication was in Norway then Norwegian deliveries = fabrication cost proportion - If fabrication was in abroad then Norwegian deliveries = 0
Engineering	- If engineering was performed in Norway <u>and</u> by Norwegian company then Norwegian deliveries = engineering cost proportion - If engineering was performed in abroad <u>and</u> by non-Norwegian company then Norwegian deliveries = 0 - If engineering was performed in Norway <u>and</u> abroad <u>and</u> by Norwegian company then Norwegian deliveries = multiplier*engineering cost proportion

Procurement	- If goods/services were delivered from Norway then Norwegian deliveries = procurement cost proportion - If goods/services were delivered from abroad then Norwegian deliveries = 0 - If goods/services were delivered from Norway and abroad then Norwegian deliveries = multiplier*procurement cost proportion
Marine operation	- If marine operation was performed by Norwegian company <u>and</u> use Norwegian-registered vessels then Norwegian deliveries = marine operation cost proportion - If marine operation was performed by non-Norwegian company <u>and</u> use non-Norwegian-registered vessels then Norwegian deliveries = 0 - If marine operation was performed by Norwegian company <u>and</u> use non-Norwegian-registered vessels <u>or</u> vice versa then Norwegian deliveries = multiplier*marine operation proportion
Project management	Project management is assumed to be significantly a Norwegian value creation as it is performed by the operators and normally uses Norwegian consultant

The multipliers used in the decision rules was obtained from different sources such as reports by respective suppliers or publication by consultants and operators or by averaging all the value of equipment and bulk that can be located from secondary sources. Once the Norwegian value added for each component is set, basic mathematical function in Table 3 is used to calculate the aggregate of Norwegian deliveries of each facility and activity. The total Norwegian value added for each project is finally obtained by adding up all aggregate values of facilities' Norwegian deliveries. Appendix E presents the complete estimation result for individual project. The estimation of Norwegian deliveries in drilling and well completion follows the same methodology by facilities development.

Table 3 Basic mathematical functions used in estimating Norwegian value creation

Function	Application
AVERAGE	Calculate the Norwegian deliveries of each activity of each facility by averaging the values of each component (as the same proportion number is shared by different sub-components)
AVERAGE	Calculate the aggregate Norwegian deliveries of each activity by averaging the values (except for marine operation, the function SUM is used instead of "average" because marine operation is not specifically attached to one component, i.e. same supplier can be used by several components)
SUM	Calculate the aggregate Norwegian deliveries of each facility

To identify the local and international content in each project this thesis examines different suppliers used in facilities and well development. Today, as it becomes a common practice for E&P companies to outsource products and services to third parties and the corresponding third parties to procure the materials and services to other parties the chain of supplies can reach up to 3 or 4 levels of sourcing before the final goods and services arrive at E&P companies (see Figure 16). However, as there is limitation in retrieving the complete information about all suppliers, the scope of analysis solely covers main contractors and first subcontractors (i.e. the upper-two levels of the hierarchy).

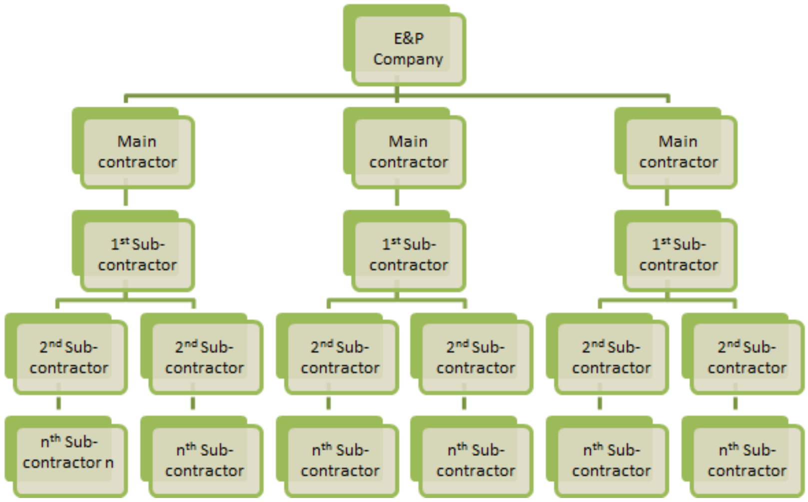


Figure 16 Illustration of supply hierarchy in field development

3 Results

Part 3 presents the evaluation of Norwegian deliveries in 2 sections: evaluation for facilities development and evaluation for drilling and well completion. Evaluation for facilities development is presented separately by project while evaluation for drilling and well completion is presented all at once for different projects. Prior to the evaluation of Norwegian deliveries, development plan of respective project is explained to give reader(s) initial understanding about the project. All information used in Chapter 3 is acquired from companies' and government's publications and other reliable supporting data from online sources.

3.1 Evaluation of Facilities Development

Estimation result of Norwegian deliveries for each specific project is presented in 2 charts: facilities-based charts and activities-based charts. Both charts display the estimation costs and Norwegian deliveries from facilities and activities point of views. In facilities-based chart, the percentage numbers represent the total Norwegian deliveries of each facility in EPC, marine operation and project management activities except for topside and substructure that only represent Norwegian shares in EPC activities. In activities-based chart, the percentage numbers represent average Norwegian deliveries of each activity in different facilities.

3.1.1 Edvard Grieg Field

3.1.1.1 Overview

Edvard Grieg field was discovered by Lundin Norway in 2007. It is located in Utsira High area of the northern North Sea, approximately 180 km west of Stavanger. The water depth in the area is around 110 meter and the field consists of two different reservoirs, Luno and Tellus reservoirs that are situated at a depth of 1930 m from the sea level. The recoverable volume of the field is approximately 26.2 million Sm^3 of oil and 49.6 billion Sm^3 of gas with production period is expected to reach 20 years depending on oil and production price trend. Plan for Development and Operation (PDO) was approved in 2012 and first oil production commenced in Q4 2015. The plan of development encompasses a fixed-steel manned platform with dry-tree wells and separate oil and gas export pipelines. Lundin Norway is the operator of the field with 50% interest and Wintershall (15%), Statoil (15%), and OMV (20%) are the partners.

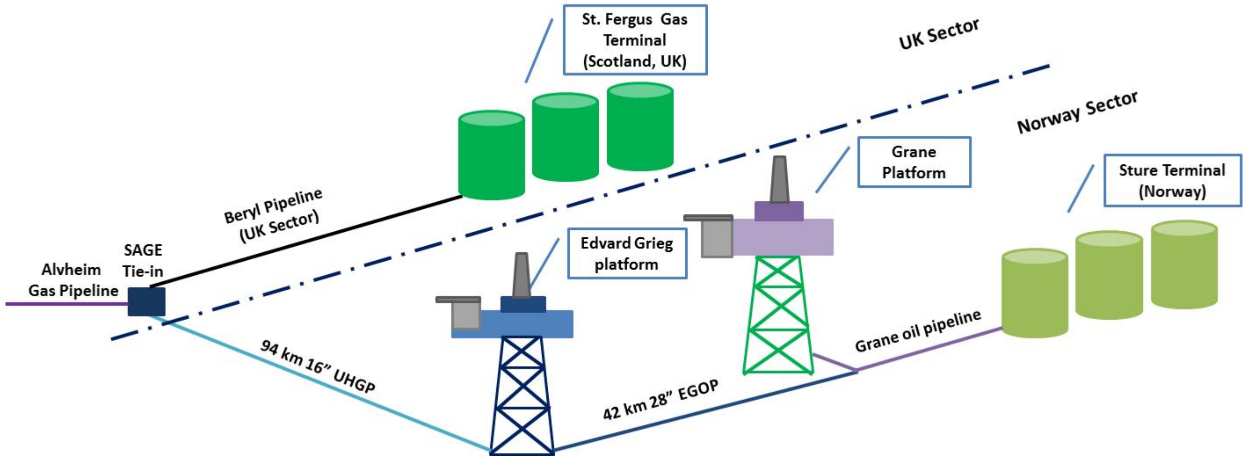


Figure 17 Edvard Grieg's field development (Statoil, 2013)

3.1.1.2 Drilling and Well

In total fifteen dry tree wells are developed to produce hydrocarbons from Luno and Tellus reservoirs. Both reservoirs represent a range of porous basement, conglomerates and high quality sandstone with excellent properties. Nine producer wells and three water-alternating-gas injectors will be drilled in Luno area while in Tellus area there will be two producer wells and one water-alternating-gas injector. The drilling campaign is estimated to drill 61 km of well trajectories which includes seven horizontal wells with the longest well has approximately 5.5 km length. A Jack-up drilling unit is used to drill all the fifteen wells and the drilling operation started right after the platfrom's jacket rested on the sea bed. To make the operation more efficient Edvard Grieg platform is designed to accommodate the simultaneous operation between drilling and completion with well intervention. Existing reservoir development plan estimates that 50% of oil and gas reserves in Edvard Grieg field can be recovered.

3.1.1.3 Platform Development

Lundin Norway develops Edvard Grieg field with fixed steel jacket platform resting on the sea bed. The topside consists of four modules that include full offshore processing module with 2 parallel inlet separators and a test separator, equipment module, flare stack, and utility module with integrated living quarter of 100 single beds and helideck, and had since been developed to accommodate tie-ins with future discoveries around surrounding areas. The topside has a total dry weight of approx. 21000 tonnes including the dry wellheads and also processes the oil and gas from Ivar Aasen platform that located 10 km from Edvard Grieg platform. The produced water from processing module is injected to the reservoir together with the treated sea water. The processed gas is exported as sales gas and used as a gas lift to assist the flow of hydrocarbon from the bottom of the well to the separator. Table 4 presents the summary of processing facility capacity.

Table 4 Edvard Grieg offshore processing module facts (Lundin Norway, 2012)

	Units	Capacity w/o tie-ins	Capacity w/tie-ins
Max. Liquids capacity	Sm^3/day	28000	28000
Max. Oil production	Sm^3/day	14300	20000
Max. Gas production	mill. Sm^3/day	2.5	5.0
Max. Gas export rate	mill. Sm^3/day	2.0	4.0
Max. Oil export rate	Sm^3/day	14300	20000
Max. Produced water treatment	m^3/day	13000	13000
Max. sea water treatment	m^3/day	20000	20000
Max. Water injection (produced water + sea water)	m^3/day	24000	24000
Max. Lift gas injection	mill. Sm^3/day	1.0	2.0
Gas export pressure	Bar	200	
Oil export pressure	Bar	160	
Inlet separator pressure	Bar	80	

Platform's substructure consists of a four-legged launch-installed jacket structure with a vertical clean face towards platform south to allow the access for an external/separated jack-up drilling unit. The total dry weight of the substructure is 13000 tons including the pre-drilling deck with 20 well slots and appurtenances of 7 supported risers, 10 caissons (7 pump caissons and 3 dump caissons) and 16 j-tubes (8 for future cables and 8 for future risers).

3.1.1.4 Pipelines and Cables Development

Hydrocarbons from Edvard Grieg and Ivar Aasen reservoirs are separated in 3-stages separator on Edvard Grieg platform before exported for further treatment. Stabilized oil is transported to existing Grane oil pipeline to be sent onwards to Sture Terminal through dedicated 43 km 29" pipelines, namely Edvard Grieg Oil Pipeline (EGOP). The new Y connection is put in the sea bed for this purpose. Rich gas is transported through dedicated 94 km 16" gas pipelines, namely Utsira High Gas Pipeline (UHGP) to SAGE-transport system pipelines in UK Continental Shelf (UKCS) to be sent onwards to St. Fergus, Scotland gas processing plant. The flow capacity of EGOP is set to 20000 Sm^3/day while UHGP is 4 million Sm^3/day.

In the early phase, two turbines power the Edvard Grieg platform. The two turbines also supply the power to Ivar Aasen platform once it comes on stream through 10-km dedicated power line. However Norwegian Ministry of Petroleum gave recommendation to create joint power supply from the shore using cable for platforms operated in Utsira High area including Edvard Grieg, Ivar Aasen, Gina Krog, and Johan Svedrup platforms (Statoil, 2012). The installation of onshore-based electrification infrastructure is planned to start in 2017 and the power delivery is expected to commence in 2018. Statoil is the operator of the development of this project. For the purpose of this study, joint power supply is not discussed in detail and excluded from value creation estimation.

3.1.1.5 Norwegian Value Creation in Facilities Development

3.1.1.5.1 Overview

Figure 18 presents the Norwegian value creation for Edvard Grieg's facilities development. In general, the development of Edvard Grieg's facilities creates a comparatively high Norwegian value creation of around 64% of overall field development costs. Platform fabrication and installation is the major contributor creates Norwegian shares at around 70% of platform's development cost while pipeline is the least with only 29% Norwegian deliveries from its budgeted cost. Activity's wise project management has the highest value added as 95% of the works were performed in Norway by Lundin's employee and Norwegian IT consultancy company Omega AS. Engineering and design, in contrast, creates smaller Norwegian shares due to significant man hours were executed from Mumbai.

Procurement, on the other hand, has the lowest Norwegian content much to the reason that steels and major equipment like compressors were imported from abroad. Similar to procurement, Marine operation also creates a small Norwegian value added at approximately 22% of its total cost as most of offshore campaign used facilities owned by International companies that use Non-Norwegian crews.

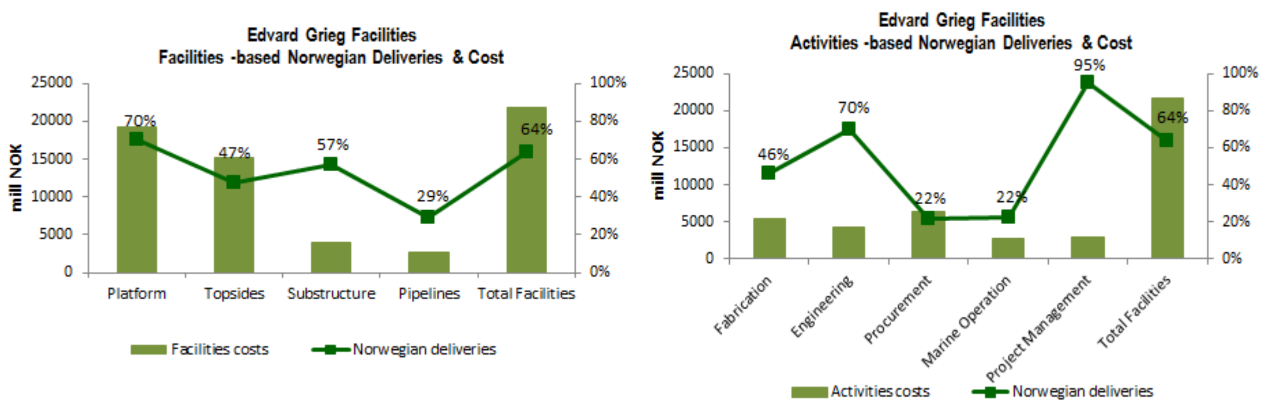


Figure 18 Norwegian Value Creation of Edvard Grieg's facilities development

To name a view is pipelaying of export pipelines that was performed by Allseas and offshore platform's installation that used crane vessel Thialf and Saipem 7000. Both Thialf and Saipem 7000 are owned by Netherland and Italian companies Heerema and Saipem and registered abroad.

3.1.1.5.2 Topside

Norwegian companies dominate the development of Edvard Grieg platform. Norwegian-owned, Kvaerner was awarded the EPC contract for fixed steel-jacket platform. Lundin also awarded Kvaerner a separate EPC contract for the substructure, and an additional contract to assist Lundin in preparing the platform for the first production after the topside and substructure has safely rested on the sea-bed (Kvaerner, 2015).

Most of the works for the topside was performed in Norway. Engineering and design were performed by Kvaerner's engineers in Oslo headquarter with a number of assistances came from Mumbai office, contributes to Norwegian share of around 82% of topside's cost allocation. For some considerations, fabrication activity was carried out in total five different yards in Norway and overseas. First, due to enormous dimension of individual module fabrication for entire modules would exceed capacity of any individual yard. Second, to make the most effective of sourcing strategy only the most capable and reliable subcontractors were awarded the contracts. Kvaerner facility in Stord was responsible to build the main deck was however steel fabrication was carried out in Poland.

EPC of processing module was subcontracted to Norwegian company Aker Solutions who executed the contract in Aker Solution's yard in Egersund, Norway. EPC of Living Quarter (LQ) and helideck was also subcontracted to other Norwegian company, Apply Leirvik AS, who built the living quarter in Apply's facility in Stord and helideck in Singapore through cooperation with Aluminium Offshore (Apply Group). The helideck was later assembled in Apply's Stord. Flare stack was delivered from Poland and assembled in offshore. Kvaerner assembled the topsides in Stord however due to the massive weight of the topsides that even the largest crane vessel Thialf reached its limit the assembly was also partly performed in offshore.

Procurement of the equipment and bulk used in topside were performed globally with Norwegian suppliers got fairly high shares. Suppliers with Norwegian billing address were mostly involved in bulk's procurement such as pumps, motors, pipes, flanges, HVAC and instrumentation systems however purchasing of equipment such as compressors and generators were mostly came from abroad[2] and so does for steels. Since cost of supply for steels constitutes the big part of procurement's cost Norwegian value creation in here is not much, around 41% in estimation. Offshore campaign used Norwegian anchor handling tug vessels to tow the topsides' modules to location in the sea and anchor them up however the lifting of the modules to mate it with the jacket used crane vessel Thialf thus Norwegian value creation in here is relatively small. Overall, total Norwegian value creation for EPC topside reaches 47% and 52% if marine installation is included.

3.1.1.5.3 Substructure (Hull)

Engineering of the substructure was completed in Kvaerner Oslo office and fabrication took place in Kvaerner jacket's-specialized facility in Verdal, Norway, produces a 100% of Norwegian shares in engineering and construction activities. Legs and bracing of the jacket were welded in Verdal however the steel pipes were purchased from abroad. Here, a German-based company EEW supplied 5,420 tonnes of structural steel pipes that was manufactured in company's plant in Erndtebrücker**,** Germany. Harland and Wolff factory in Belfast, North Ireland, supplied clusters of the jacket. The rest of the components such as risers, j-tubes, caissons, and control cables, however, were domestically supplied though most of components'

[2] Example of Norwegian suppliers includes Delta-p AS, Energy Piping AS, Eureka Pumps AS, Teamtrade AS, and Novenco AS (INTSOK, 2013). Equipment suppliers were including Siemens Germany and Siemens Netherland who supplied re-compressor and injection compressor and GE Power who supplied gas turbine

materials were imported. All in all Norwegian shares in materials' procurement for the jacket is moderate of around 34% of allocated cost for procurement.

Offshore installation of the jacket used Norwegian vessels to tow and anchor the structure into the field's location and crane vessel Saipem 7000 to lift and position the jacket on the sea bed. Saipem subcontracted UK-based DeepOcean to perform the foundation grouting of the sea bottom. As expected, the Norwegian content in offshore operation is very small around 3% from the total substructure's cost. In total, Norwegian share for the EPC and Installation of Edvard Grieg's jacket is slightly moderate at a level of 57%.

3.1.1.5.4 Export Pipelines

Development of Edvard Grieg's oil and gas pipeline demonstrates a modest share of Norwegian content calculated at a level of 16% for each pipeline system and a total of 29% including the connection works to existing pipelines' network. In general, Norwegian suppliers have a very low share in this area. Steel pipes are usually purchased from steels' producer countries like Japan and India and coated in Malaysia or Scotland. International players most notably Allseas, a Switzerland-based and Saipem, a Italy-based company dominate installation contract. For Edvard Grieg, steel pipes were supplied by Welspun in India and coated by Bredero Shaw in Scotland, creates no Norwegian values in steel pipes procurement. Allseas Solitaire, a Malta-registered vessel executed the pipelaying creates small Norwegian shares from local supply of installation's equipment.

Even so, small Norwegian portion was still noticeable through several important works. Engineering and design works were 100% Norwegian shares since the work was awarded to J.P Kenny and IKM Norway. Both companies executed the work from its Stavanger offices using their Norwegian consultants. In a same manner, Technip Norway also contributes a significant Norwegian share. Technip was responsible to provide diving services, including pipeline repair system equipment, to connect Edvard Grieg's oil and gas pipelines to existing pipelines networks. Engineering and equipment fabrication we

3.1.2 Ivar Aasen Field

3.1.2.1 Overview

Ivar Aasen field development comprises of three different reservoirs, Ivar Aasen, West Cable, and Hanz reservoirs that are located in Utsira High area in the northern North Sea, near Edvard Grieg field. The biggest deposit is Ivar Aasen which was discovered in 2008 by Det Norske Oljeselskap whereas West Cable was discovered in 1994 and Hanz in 1997, both by Esso. The water depth in the area is around 113 m and oil-water contact is found at a depth of about 2400 m below sea level. The recoverable volume of the three discoveries is estimated 26.5 million Sm^3 for oil and 4.9 billion Sm^3 for gas provide anticipated economic life of the field to 20 years. Norwegian authorities approved the PDO in 2013 and the first oil production is expected in Q4 2016.

There are two development phases where first phase consists of Ivar Aasen and West Cable reservoirs and second phase of Hanz discovery. First phase will be developed using dry-tree wells mounted on fixed steel-jacket platform while second phase with subsea wells connected to the platform. Overall, the development of Ivar Aasen field is line up with development of Edvard Grieg by Lundin Norway. Det Norske is the operator of the field with 34.7% interest and Statoil, Bayergas, Wintershall, VNG, Lundin, and OMV are the partners with 41.4%, 12.3%, 6.4%, 3%, 1.3%, and 0.5% of shares respectively.

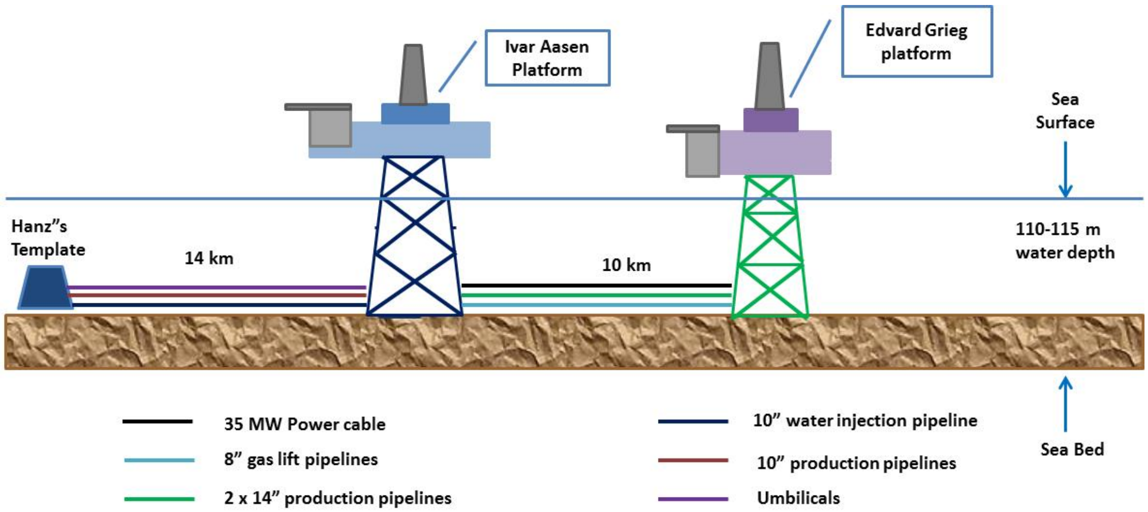


Figure 19 Ivar Aasen's field development (Det Norske, 2013)

3.1.2.2 Drilling and Well

Ivar Aasen field is planned to be drained with total 15 wells comprises of 6 producing wells and 6 water injection wells for Ivar Aasen reservoir, 1 producing well for West Cable, and 1 producing well and 1 water injection well for Hanz fields. Development of the Hanz field, however, will commence in the second phase, depending on the available processing capacity (Norwegian Petroleum, 2015). Drilling of the wells is performed using dedicated external Jack-up rig at which the rig has a drilling tower that can be moved across Ivar Aasen platform so the drilling is performed through the platform instead. The drilling campaign is estimated to drill 4.26 km of well trajectories for Ivar Aasen reservoir, 6.90 km for West Cable and 3.27 km for Hanz. The existing plan expects to get recoveries factors of about 39% in Aasen, 50% in West Cable, and 63% in Hanz (Det Norske, 2012).

3.1.2.3 Platform Development

Development with fixed steel-jacket manned platform is chosen for Ivar Aasen field. The platform consists of topside and substructure and situated 10-km West of Edvard Grieg platform. The topside is equipped with processing facility including gas compression and water injection unit as well as integrated living quarter with helideck, and flare tower. The hydrocarbon from reservoir is going through one-stage separator and the produced oil and gas are delivered to Edvard Grieg platform for further processing. The produced water is mixed with sea water before re-injected to Ivar Aasen and Hanz reservoirs and to prevent scaling and corrosion in production equipment sulfate in the sea water is removed using specialized de-sulphatation unit.

In the early production period, Ivar Aasen platform gets its supply of electricity from Edvard Grieg platform and as early as 2018, joint power plant will electrify the platform from land through joint power. Aside from electricity, Edvard Grieg platform also delivers gas lift to Ivar Aasen's reservoirs to help producing the hydrocarbons. Overall, the platform's topside has operating dry weight around 15000 tonnes with 20 dry-tree well slots and living quarter that can accommodate up to 70 single beds. The substructure has operating dry weight of approximately 9000 tonnes and completed with four pieces preinstalled risers and a number of J-tubes for pulling flowlines and umbilicals for Hanz development and for future third-party fields (Det Norske, 2012). The summary of the processing facility capacity is presented in Table 5.

Table 5 Ivar Aasen offshore processing module facts (Det Norske, 2012)

	Units	Capacity
Max. Liquids capacity	Sm^3/day	21000
Max. Oil production	Sm^3/day	9000
Max. Gas production	mill. Sm^3/day	3.0
Max. Gas export rate	mill. Sm^3/day	3.0
Max. Oil export rate	Sm^3/day	9000
Max. Produced water treatment	m^3/day	20000
Max. sea water treatment	m^3/day	20000
Max. Water injection (produced water + sea water)	m^3/day	28000
Max. Lift gas injection	mill. Sm^3/day	1.4
Gas export pressure (to Edvard Grieg)	Bar	60
Oil export pressure (to Edvard Grieg)	Bar	60
Inlet separator pressure	Bar	31

3.1.2.4 Subsea System Development

Subsea well is used to exploit Hanz reservoir in Ivar Aasen field. One producing well and one water injection well are connected to Ivar Aasen platform through a 4-well slots subsea template, 1 x 14 km-10" production flowline, and 1 x 14 km-10" water injection pipeline. Supply of electric power, control signals, hydraulic fluids and chemical to the wellheads uses a 14 km umbilicals and a 14 km-4" gas lift pipeline is laid to expedite lifting the hydrocarbon from the well. For the maintenance purpose such as cleaning and inspecting the flowline, a pigging installation is installed. Since Hanz deposit will be developed as the second phase of Ivar Aasen field development, the arrangement of subsea system hasn't bring into live.

3.1.2.5 Pipelines and Cables Development

Produced oil and gas from Ivar Aasen platform is transferred to Edvard Grieg platform for further processing. The transportation is carried out through two 10-km pipelines with 14" outside diameter. The flow capacity for each of the pipeline is 9000 Sm^3 of oil and 3 million Sm^3 of gas. Once processed, the EGOP transfers the crude oil to Sture Terminal whereas UHGP transfers the rich gas to St. Fergus gas processing plant in Scotland. In regards to this arrangement, Det Norske participation in the two pipelines projects is established through 21%

and 14% stakes on the projects' ownership, respectively, yet takes place in a form of tariffs instead of capital expenditures (Det Norske, 2013).

The construction of the EGOP and UHGP becomes the responsibility of Statoil, the partner of both Edvard Grieg and Ivar Aasen fields, and the operatorship of EGOP will be under Lundin Norway while UHGP will be operated by Gassco. The decision to have one transportation solution between Edvard Grieg and Ivar Aasen is made based on recommendation from Gassco, with consideration that the same infrastructure can be used as future transport solution for another field development in surrounding area (Statoil, 2013). Aside of two 10-km 14" pipelines, there is also 1x10-km 8" pipeline and 1x10-km 35 MW power cable between Ivar Aasen and Edvard Grieg platforms to flow the gas lift and electricity from Edvard Grieg's to Ivar Aassen's.

3.1.2.6 Norwegian Value Creation in Facilities Development

3.1.2.6.1 Overview

Figure 20 presents Norwegian value creation in Ivar Aasen's facilities development. Here, development of subsea production system for Hanz reservoir is included even though the actual contract has not been awarded while this report is written. The detail development plan of the subsea system, however, is well stated in *Impact Assessment Sections of Ivar Aasen's PDO* that was published in government official website (Regjeringen, 2012). The calculation of Norwegian content is subsequently adheres to the published information with particular assumptions were made in regards to general suppliers of the subsea systems.

In general, the development of Ivar Aasen facilities makes up a total of 44% Norwegian value added. Platform's development generates a relatively low contribution to Norwegian society as fabrication of both topside and substructure were completed in other countries. Development of subsea system, however, generates modest Norwegian shares as the structure would most likely be delivered by Norwegian suppliers and manufactured in Norway. Export pipelines also creates a moderate Norwegian shares as fabrication was taking place in Norway although most materials were imported. Power cables, on the contrary, produces a small Norwegian values since fabrication and procurement were taking place in other country and only installation work that occupy local contractors.

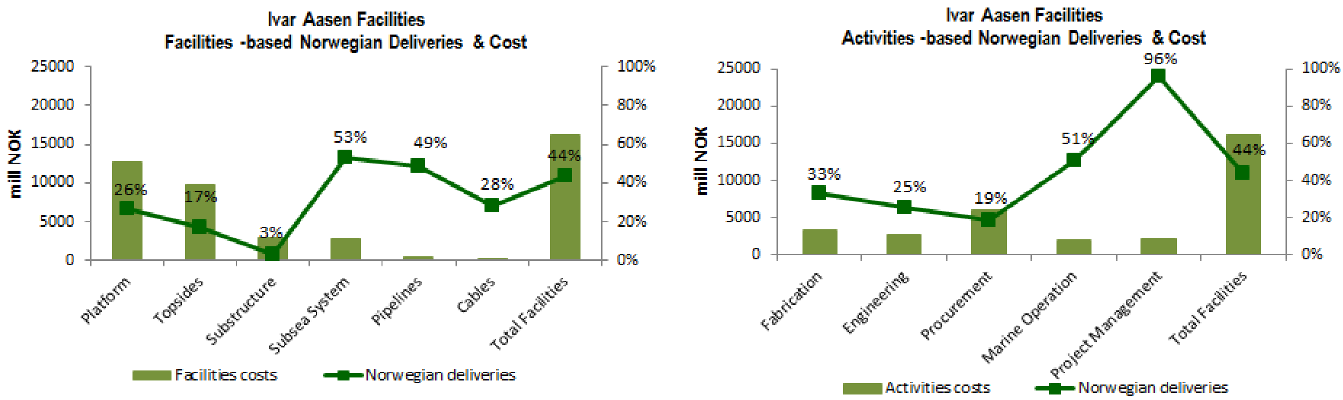


Figure 20 Norwegian Value Creation of Ivar Aasen's facilities development

3.1.2.6.2 Topside

Development of Ivar Aasen topside delivers a less significant value creation for Norway. The calculations estimates only 17% of facilities' development budgets return to Norwegian society. EPC of topside was awarded to Singapore-based Sembcorp Marine Ltd[3]. Wood Group Mustang was subsequently contracted by Sembcorp to do engineering work while EPC for living quarter was awarded to Apply Leirvik. Wood Group executes the engineering contract from its London and Kuala Lumpur office and Apply Leirvik from Norway office. In total only small Norwegian shares occurred in engineering activities, estimated at less than 20%. Sembcorp fabricates the topside in Singapore and Indonesia with Norwegian contributions mostly comes from equipment and bulk deliveries[4]. FMC Norway supplied Christmas trees and wellheads where manufacturing were partly done in France and Scotland. Overall Norwegian value added for equipment & bulk deliveries (include Xmas trees & wellheads) is roughly 28% of topside's development budgets.

Apply Stord built the living quarter in Norway with high portion of components come from Norwegian suppliers. Helideck, however, was built in China and assembled with the living quarter in Stord. All in all, portion of Norwegian parts in EPC living quarter is quite high estimated at a level of 69% of Apply's budgeted cost. Transportation of topside from Singapore to Norway was awarded to Saipem who uses non-Norwegian vessel and offshore installation is planned to use crane vessel Thialf. Platform hook-up was awarded to Aibel who executes the work at EPC contractors (i.e. Singapore and London) and offshore. Overall, estimate of Norwegian value creation for EPC and marine operation of topside including transportation and offshore hook-up is around 21% of total facilities' development budget.

[3] The development of the topside is still on progress and expected to be finished on June-July 2016.

[4] Several of Norwegian suppliers include Novenco AS, Draka Norsk Kable, Autronica Fire & Security AS, Torgy Mek Industry AS and Siemens AS. Siemens AS in particular is awarded large EPC packages consisting of water-desulphatation equipment and integrated control and communication system. Major equipment, however, is dominated by foreign suppliers such as MAN Switzerland & MAN Germany who supply HOFIM™ compressors.

3.1.2.6.3 Substructure (Hull)

Det Norske awarded EPC contract of Ivar Aasen substructure to Saipem. Saipem performed the engineering in London office and fabrication was executed in Saipem's yard in Sardinia Island, Italy. In addition, Saipem was also awarded contract to transport and install the jacket, topside and living quarter. Jacket had been installed on the sea bed since June 2015 using a crane vessel Thialf. Right after jacket installation, pre-drilling of production and injection wells over the top of jacket was commenced using jack-up rig Maersk Interceptor. Here a total of pretty small Norwegian content, approximately 4%, is predicted which most likely comes from logistic used during installation.

3.1.2.6.4 Export Pipelines and Cables

EPC and installation (EPCI) of export pipelines, including pipeline end termination (PLETs) and spools, was awarded to EMAS AMC. Engineering and project management were 100% Norwegian portions as EMAS executed the work in Oslo HQ. EMAS's Halsvik spool base in Gulen, Norway was used as service based and fabrication of welded pipe components was completed there creates a 100% Norwegian value creation for fabrication. Steel pipes for the pipelines were procured from abroad and welded in Gulen, PLETs and spools were delivered from EMAS facility in USA and other equipment were mostly imported. Marine operation was performed using EMAS owned vessel that is not registered in Norway however several Norwegian crews are onboard. In total, Norwegian value creation for EPCI and project management of the pipelines is roughly 49%.

Det Norske awarded power cables contract to ABB, a major player in this segment. EPC works was carried out from ABB facility in Karskrona, Sweden generates no Norwegian value added. Installation of the cables, however, produces a moderate Norwegian values since the work was performed by Norwegian subsidiaries of EMAS. Subsequently, the estimated Norwegian value added for power cables development is something like 28% of total facilities' costs.

3.1.2.6.5 Subsea System

As discussed in the overview section, contract for subsea system has not been awarded upon this thesis is written. Thus, estimation of Norwegian value creation was done by assuming similar subsea contractors that employed by other fields in analysis. EPCI contracts are assumed to be rewarded to Norway-based suppliers (Norwegian-owned or Norwegian subsidiaries) since Norwegian have a very strong competence in this segment. Key players in subsea system such as Aker Subsea, Subsea 7, FMC Technologies, and Technip are all have office and production facility in Norway makes engineering and fabrication will most likely be locally performed[5]. Procurement, however, are procured from local market and greatly from overseas reduces overall Norwegian value creation. Several of big players have their own vessel to perform offshore

[5] Several major subsea contractors also have production facilities outside Norway. Aker Subsea produces wellheads and control systems in Scotland but templates and Xmas trees are fabricated in Norway. FMC produces Xmas trees and wellheads in Scotland but other subsea components are fabricated in Norway. GE doesn't have significant production in Norway. Subsea 7 and Technip, major players in SURF (Subsea Umbilicals, Risers, and Flowlines) segment, have main fabrication facility in Norway but flexible pipes and risers are fabricated in other countries (Agenda Kaupang, 2015).

installation however not all of the vessels are exclusively deployed in Norwegian Continental Shelf[6]. Those which registered in Norway are completed with Norwegian crew on board and generate higher Norwegian value added. In summary, development of subsea system delivers Norwegian value added of nearly 53% from total facilities costs.

3.1.3 Aasta Hansteen Field

3.1.3.1 Overview

Aasta Hansteen field encompasses three discoveries, Luva, Haklang, and Snefrid South and located in the Northern Norway on the Norwegian Sea, 320 km west of Bodø. The biggest deposit, Luva, was discovered by BP Norge in 1997 and acquired by Statoil in 2006 while Haklang and Snefrid South were discovered by Statoil in 2008. The field lies in 1300 m below the sea level and contains large deposit of gas and some condensate. The total recoverable volume is estimated at 45.5 billion Sm^3 for the gas (Luva 35.5 billion Sm^3, Haklang 6 billion Sm^3, and Snefrid South 4 billion Sm^3) and 0.9 million Sm^3 for condensate. The reservoirs lie in a depth of 4000 m from the sea level.

Norway authorities approved the PDO in 2013 with first production plans to commence at the end of 2018. Aasta Hansteen field is developed with 3 templates of wet tree wells connected to SPAR floating production platform. The produced gas is transported to onshore gas processing plant in Nyhamna, currently operated by Shell Norske A/S for Ormen Lange field, via dedicated gas pipelines (Polarled gas pipeline and the condensate is temporarily stored in the platform's substructure before transported to shore by chartered tanker. Statoil is the operator of the field with 51% stakes followed by Wintershall (24%), OMV (15%) and ConocoPhillips (10%).

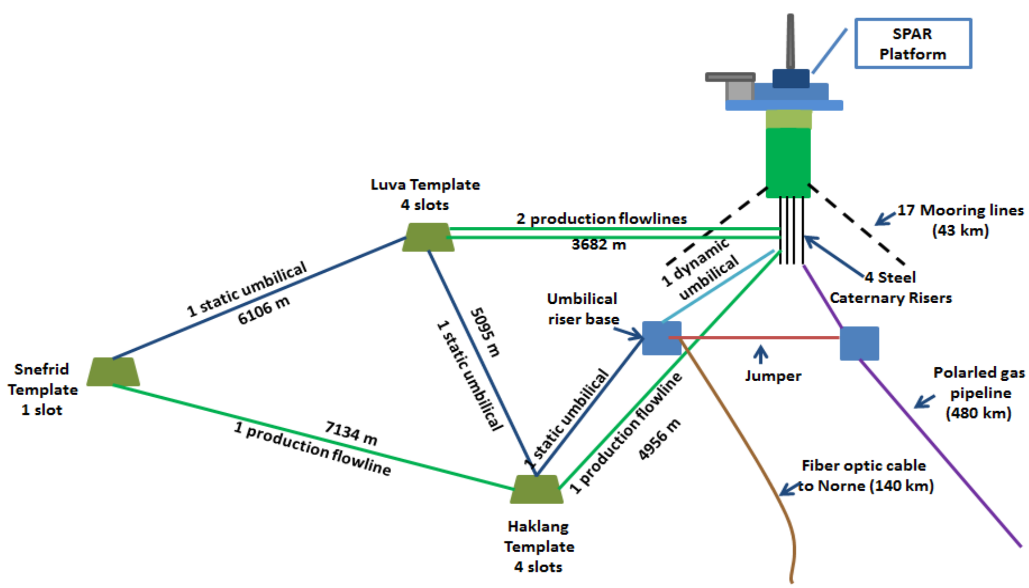


Figure 21 Ivar Aasen's field development (Statoil, 2012)

[6] Technip's and EMAS's installation vessels are all registered abroad and deployed in other continental shelf as well whereas Subsea 7 have several vessels that are registered in Norway and exclusively used in Norwegian continental shelf.

3.1.3.2 Drilling and Well

In total Aasta Hansteen field will have 7 subsea wells: 4 production wells in Luva discovery, 2 production wells in Haklang, and 1 production well in Snefrid South. The recovery strategy is a pressure depletion with pressure support from an aquifer resulting an estimated recovery rate of 69% for the gas and 59% for condensate. In addition, external semi-submersible drilling rig is used to drill the wells.

3.1.3.3 Platform Development

Aasta Hansteen SPAR platform is the first SPAR installation in Norway's petroleum history and marked the first deep water floating production platform installed in north of Arctic Circle. It is also the world's largest SPAR to date and the first SPAR with FPSO concept. The platform consists of topsides and substructure where topside is completed with conventional gas processing unit (including gas conditioning and dehydration), water treatment area, living quarter with capacity of 100 single-beds, helideck, flare tower, utility module, and gas turbine power generation for platform's electricity.

The substructure has diameter of 50 m and length 198 m and completed with condensate storage. Planted inside the hull are 4 steel catenary risers (3 production SCRs 12 ¾" OD, 1 gas export SCR 14"OD) with 12 riser slots and 4 umbilicals (3 static-18 km long, 1 dynamic-1.3 km long). 17 polyester mooring lines, 43 km in total and 17 suction anchors will taut the hull to the sea bed. The estimate of operating dry weight for the topside is 22600 tonnes while the substructure is around 41000 tonnes. The produced water from processing area is going to be treated before discharged to the sea and the gas is exported to shore via Polarled gas pipelines. Fiber optic cable is installed in the sea bed and connected the platform with existing infrastructure near Norne.

Table 6 Aasta Hansteen offshore processing module Facts (Statoil, 2012)

	Units	Capacity
Max. Liquids capacity	Sm^3/day	1000
Max. Condensate production	Sm^3/day	900
Max. Gas production	mill. Sm^3/day	23.0
Max. Gas export capacity	mill. Sm^3/day	24.7
Max. Condensate storage capacity	Sm^3/day	25000
Max. Produced water treatment	m^3/day	100
Gas export pressure	Bar	115 – 230
Condensate export pressure	Bar	20
Inlet separator pressure	Bar	86

3.1.3.4 Subsea System Development

Subsea system for Aasta Hansteen field development consists of three subsea templates (with manifolds) tied back to the SPAR platform. Two templates with each 4 well slots are situated in Luva and Haklang discoveries and one template with 1 well slot is situated in Snefrid South. Luva and Haklang templates are immediately tied-back to the SPAR while Snefrid South template is tied back to Haklang's. There are 2 production flowlines to channel the well streams from Luva template to SPAR, 1 production flowline from Haklang's to SPAR, and 1 production flowline from Snefrid South's to Haklang's. Three static umbilicals are placed between Luva template and Snefrid South's, Luva template and Haklang's, and Haklang template and umbilical riser base. One dynamic umbilical, on the other hand, is prepared as the connection of static umbilical in the sea bed to the platform. The flowlines are mechanically line pipe and so as the spools.

3.1.3.5 Pipeline and Cable Development

Pipeline consists of gas export pipelines lying on the sea bed from the platform to onshore Nyhamna gas processing plant in Møre and. The total length of the pipelines is 480 km with outer diameter 36 inches, wall thickness ranging from 28.9 to 43.4 mm, and flow capacity of 70 million Sm^3 of gas per day. The *Polarled* gas pipeline, as it is called, is the world's first gas infrastructure that crosses the Arctic Circle and the first 36 inches gas-carrying pipeline placed in a deep water area (Statoil, 2015). As of today, the flow capacity of the pipeline is larger than gas production capacity of the Aasta Hansteen for purposes that *Polarled* pipeline would attract further exploration works in the surrounding area, given that the transport solution for future field development is available, and as the new artery of the gas supply to Europe from a completely new region (Statoil, 2015).

The *Polarled* pipeline is a part of Polarled Development Project which is counted as a different project from Aasta Hansteen field development. Aside from gas pipeline the scope of Polarled Project also includes expansion and modification of Nyhamna processing plant, connection of Polarled pipeline to Åsgard transport system through 30 km-18" branch pipeline to Kristin platform, possible branch pipelines 60 and 173 km South of Aasta Hansteen, and possible tie-in with Linnorm field via Draugen and Zidane field via Heidrun (Statoil, 2015). In addition to gas pipeline, 140 km of fiber optic cable for data transmission and communication system is placed in the sea bed from Aasta Hansteen platform to existing infrastructure near Norne.

3.1.3.6 Norwegian Value Creation in Facilities Development

3.1.3.6.1 Overview

Aasta Hansteen field development is another important milestone for Norwegian petroleum industry. Its ripple effects has enable Northern region of Norway to emerge as a new industrial base. Many regional suppliers are invited to involve in the project and new investments on production and supply facilities are made. Among of these, Wasco Coating decided to build a new production workshop in Mo i Rana, Aker Solutions expanded its working facilities in Sandnessjøen, and Helgelandbase AS built a new supply base in Sandnessjøen for clients BP and Statoil. These facilities perform significant amount of inshore operations for subsea equipment and gas pipelines and expects to generate considerable ripple effects for many local suppliers. Moving forward, the new facilities are expected to deliver more services to national oil and gas industry and attract more E&P companies to explore new geographical area in Northern part of Norway.

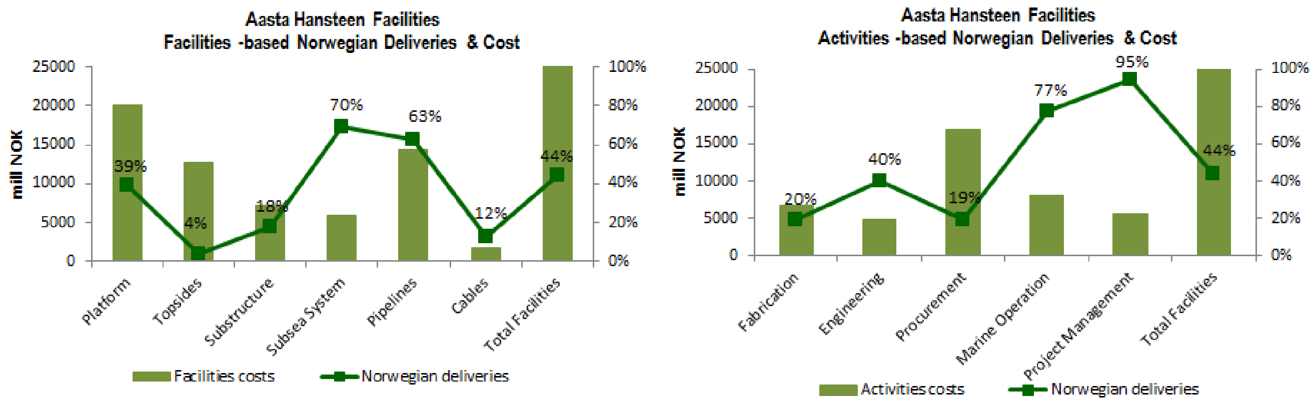


Figure 22 Norwegian Value Creation of Aasta Hansteen's facilities development

In general, from the total budgeted money to develop production facilities in Aasta Hansteen field, 44% is estimated return to Norway's society as an added value. Project management essentially is pure Norwegian value added as Statoil in-house team carries out the work. Marine operation is largely a Norwegian shares that mostly comes from platform and subsea installation. Engineering, on the other hand are fairly Norwegian ownership since the activity are performed in Norway and several other countries and so does fabrication and procurement. EPCI and project management of SPAR platform creates a modest Norwegian content of nearly 40%. Here, fabrication works doesn't generate substantial Norwegian value added since the activity is carried out in outside Norway. Procurement of different kind of process equipment and small devices like pumps and motors, however, bring much value creation to suppliers with Norwegian billing address, increase overall local contributions.

As expected, subsea system delivers a significant Norwegian value creation, estimated around 70%, as majority of development works are performed in Norway using Norwegian human and technical resources. Similar to subsea system, *Polarled* gas pipelines project also generates a quite high share of Norwegian content, around 61% from the total project value, as significant works including welding and coating are performed in Northern Norway. Fiber optic cable, on the contrary, doesn't have Norwegian contractors on its procurement and installation and only generates very small Norwegian value added from engineering and project management.

3.1.3.6.2 Topside

Statoil awarded EPC and Hook-up contract of Aasta Hansteen topside to Hyundai Heavy Industries (HHI) which currently in the progress of fabrication in HHI facility in Ulsan, South Korea. HHI subcontracted engineering & design to Chicago Bridge & Iron (CB&I) who executed the work from CB&I offices in Singapore and Netherland creates no Norwegian value creation. Steels are sourced from Korean steel producers whereas equipment and bulk comes from local suppliers in Korea as well as other foreign suppliers including Norway. Norwegian shares in here are mostly coming from procurement of different kind of topside and process equipment.

EPC of living quarter and helideck was subcontracted to Hertel Offshore who executes the contract from its office and facilities in Netherland. Norwegian value creation in here is minimal, less than 3% from overall platform's costs, and comes from agreement between Hertel Offshore and Norwegian suppliers on equipment deliveries. The agreement makes up around 30% of overall contract's value. Now, the living quarter and helideck has safely assembled to the main deck in Ulsan and once the structure is complete it will be transported to Norway using Dockwise new fleet *White Marlin* produces no Norwegian value added in the process.

Inshore and offshore hook-up and commissioning are subcontracted to Kvaerner. Kvaerner will carry out the onshore works in in Stord and once the process complete Kvaerner will mate the topside with its hull in Diggernessundet deep water site. Heavy lift vessel will be used during the mated process that doesn't belong to Norwegian companies. Overall, EPC of topside is estimated to generate very small Norwegian shares, less than 5% from its capital spending but marine operation's delivers more significant Norwegian values of around 45%.

3.1.3.6.3 Substructure (Hull)

Substructure EPCH contract was granted to consortium of Technip and Hyundai Heavy Industries (HHI). Technip performed engineering and design from office in Houston, produces no Norwegian value added in the process. Equipment and bulk are delivered from different parts of the world and only small shares of pumps, motors and other small devices come from Norwegian companies. Statoil appointed Netherland-based Lankhorst Ropes to supply 17 polyester mooring lines from its facility in Portugal admits no Norwegian value added in the process. Subsea 7 is awarded EPCI contract to deliver 4 steel catenary risers (SCRs). Fabrication takes place at Subsea 7 facility in Vigra, Norway and materials mainly come from abroad. Once the hull ready, Dockwise largest vessel, *Dockwise Vanguard* will transport the hull to Norway leads to no Norwegian deliveries in the process.

In a separate contract, Statoil also selected Subsea 7 to install and hook-up the mooring lines to the hull, tow-out SPAR platform to the field, and pre-commissioning the hull. All offshore campaigns, including for subsea equipment, use a total of seven Subsea 7 owned-vessels where two of it are registered in Norway and use Norwegian crew on board. Tow-out operation, however, will use third party vessels which most likely Norwegian vessels. Kvaerner, on the other hand, is subcontracted by Technip to provide services and assistance during mooring, upending, ballasting, and installation of predefined equipment as well as preparation of the hull before mating it with topside. The activity will be performed in Kvaerner deep water site in Digernessundet. All in all, EPC of substructure including SCRs and mooring lines is estimated to deliver 18% Norwegian shares. In contrast, marine operation delivers higher Norwegian shares close to 58%.

3.1.3.6.4 Subsea Equipment

Subsea equipment including SURF, spools, PLETs/PLEMs, templates, manifolds, Christmas trees, wellheads and suction anchors are largely a Norwegian ownership. Norwegian contractors have the competence and ability to produce and supply the subsea equipment from several places in Norway, including Northern region. Import is associated with procurement of some materials such as steels, pipes, and any other steels components. Statoil signed agreement for deliveries of different subsea equipment with two major subsea contractors Aker Solutions and Subsea 7.

The contract for Aker Solutions comprises deliveries of subsea template and manifolds, umbilical and umbilical riser base, subsea Christmas trees, subsea wellheads and control system. Several Aker Solution branches in overseas: Scotland, London, Houston, Mumbai and Kuala Lumpur are participating in engineering and procurement works. Aker facility in Sandnessjøen is served as a service base and fabrication workshop for templates. EMAS is responsible to install the template and procure the necessary equipment from Momek and other local suppliers. Umbilicals and umbilicals riser base, manifolds, Christmas trees and control system are all produced in facilities in Norway (Moss, Egersund, and Tranby respectively) while wellheads is fabricated in Aker's factory in Scotland. Materials are largely supplied by foreign suppliers but several Norwegian companies also involves in the process.

Separately, Statoil awarded Subsea 7 the other major subsea contracts. The contracts consist of EPCI of flowlines and flowlines piles, EPCI of PLETs, EPCI of spools, installation of umbilicals and umbilical riser base, installation of manifolds, and tie-in of flowlines and umbilicals. Procurement of equipment and bulk largely come from abroad but Norwegian companies are heavily awarded by Subsea 7 to provide most of the services. Aker Solutions in Sandnessjøen is awarded to deliver spools and spreaders while flowlines are prepared in Subsea 7 spool base in Vigra. Subsea 7 also signs agreement with Momek Group AS for delivery of 25 anchor suctions. The agreement has created considerable ripple effects to local suppliers in Northern Norway. Production takes place at Momek facility in town of Mo i Rana, North of Norway. Steel material is purchased from abroad but services such as surface treatment and welding inspection are provided by local suppliers.

Engineering and supply chain management is pure Norwegian ownership as Aker and Subsea 7 executes the works in offices in North of Norway. Marine operation by Subsea 7 and EMAS also largely a Norwegian value creation having using Norwegian crew and equipment from domestic suppliers. Norwegian content in here is estimated reaches 80% of budgeted spending for marine operation. In total, subsea equipment generates a considerable Norwegian value added of nearly 70% of its development cost and from here Norwegian share in EPC flowlines is estimated at 40% of its budgeted investment, umbilicals at 32%, templates and manifolds at 44%, and Christmas trees at 35%.

3.1.3.6.5 Polarled Gas Pipelines and Cables

Development of *Polarled* gas pipelines are partly Norwegian value creation and some important local achievement are noteworthy to mention. Main engineering and design was awarded to Rambøll who executed the work in Copenhagen, Denmark. Small Norwegian shares are present through third parties verification by Reinertsen, a Trondheim-based EPC company. Consortium of JFE Steel and Marubeni-Itochu were awarded pipelines fabrication contracts. All the work was done in Japan so there isn't any Norwegian share created in this process.

After the fabrication, steel pipes were sent to Wasco in Malaysia to apply outer corrosion coating and inner float stability coating. Again, no Norwegian shares created in this step. From Malaysia, pipelines were transported to Wasco facility in Mo i Rana where exterior concrete ballast coating was applied and sacrificial anodes was installed. Statoil awarded Bergen-based transporter, Grieg Shipping a contract to transport the pipes from Malaysia. Norwegian value creation in here is estimated 80% of the contract's value. Another 20% is expenses that incurred abroad during the trip. In total, coating activities generates Norwegian value added at approximately 50% of its investment budget.

After coated, pipelines were sent to warehouse in Mo i Rana and Vestbase (Averøy) Kristiansund for temporary storing. Batch by batch of steel pipes were transported from warehouse to on-site pipelaying vessel for installation. Every day, there were six boats in shuttle traffic to continuously supply the pipes and all of them are Norwegian boats. Significant ripple effects for local economy were generated in here as logistic of equipment and other necessities were coming from local suppliers. Allseas performed the installation works which generates a modest Norwegian value creation. Engineering work was performed from Allseas office in Netherland and installation were executed using one of world's largest pipelaying vessels, *Allseas Solitaire*. The vessel was completed with 420 people and most of them, if not all, are non-Norwegian. Every week, 50 crews will be transported to and fro vessel and spend one night in land generates Norwegian value added for local economy from helicopter and accommodation services.

Majority of equipment are inherent parts of the vessel and only small portion were supplied by subcontractors. From total value supplied by subcontractors, around 80% were coming from Norwegian suppliers. Norwegian suppliers was awarded contract to provide gravel, repair service for damage parts, and special kind of plug to seal any leak in addition to all support service in the land such as helicopter, supply base, catering, and other necessary logistic. Allseas also awarded Norway-based Baker Hughes for backup services in case of damage during the laying process. In total, 40,000 steel pipes with 12.2 m long each were welded and protected onboard of *Allseas Solitaire* and subsequently placed in the sea bed. The process was started in March 2015 from Nyhamna and ended in Aasta field on September 2015 where 4 km of pipes were laid every day.

In separate contracts, Statoil awarded DOF Subsea and Deep Ocean a framework agreement to provide services and light construction work for *Polarled* pipeline project and assist *Allseas Solitaire* at different times of assignments. The works included pre-lay surveys, trenching, counterweight installment, pull-in wires installment, installation of PLEM, meteorological data collection, post-lay surveys, and startup assistance. Norwegian value creation in here is comparatively high, more than 80% of budgeted money as Norwegian suppliers were heavily used throughout the operation. Works were carried out using special vessel and both companies used Norwegian vessels with Norwegian crew onboard. Deep Ocean leased the vessels from Ålesund-based Vollstad Shipping and supplied all necessary equipment through Vollstad although most of the components were purchased from abroad. DOF Subsea used its owned vessel and purchased all equipment from local suppliers (mostly from Bergen).

In addition to gas pipeline installation, *Polarled* pipeline project also installed several subsea structures. The structures include connection points for tie-in existing pipes to future pipelines network and PLEM that connect the *Polarled* pipelines to platform's risers. Kongsberg Oil and Gas Technology was awarded the EPC contract for these structures. Engineering was executed in company headquarter in Asker and fabrication in facility in Drammen. Material procurement were mainly comes from suppliers in Norway with biggest suppliers were Aker Solutions, Nemotech, and FMC Norway. Norwegian value creation for this EPC contract is estimated nearly 90% of investment costs. All in all, *Polarled* gas pipeline is estimated to deliver an approximately 63% Norwegian shares from its investment budgets and the biggest shares come from project management with about 90% Norwegian deliveries and marine operation (including pipe transfer from Malaysia and offshore works from DOF Subsea and Deep Ocean) around 73% Norwegian deliveries.

3.1.4 Gjøa Field

3.1.4.1 Overview

Gjøa oil and gas field was discovered in 1989 by Norsk Hydro and is located in the Northern area of North Sea, approximately 50 km Northeast of Troll field and 65 km southeast of Fløro. The field lies in 360 meters water depth and the reservoir depth is around 2200 meters from sea surface. Total recoverable volume of oil is 13.2 million Sm3 and gas 35.7 billion Sm^3. The PDO was approved in 2007 and the first production was commenced in 2010. Statoil is the operator of development phase while Gas de France (30%) is the operator in the operation phase. Other partners include Petoro (30%), Wintershall (20%), Norske Shell (12%), and RWE DEA (8%).

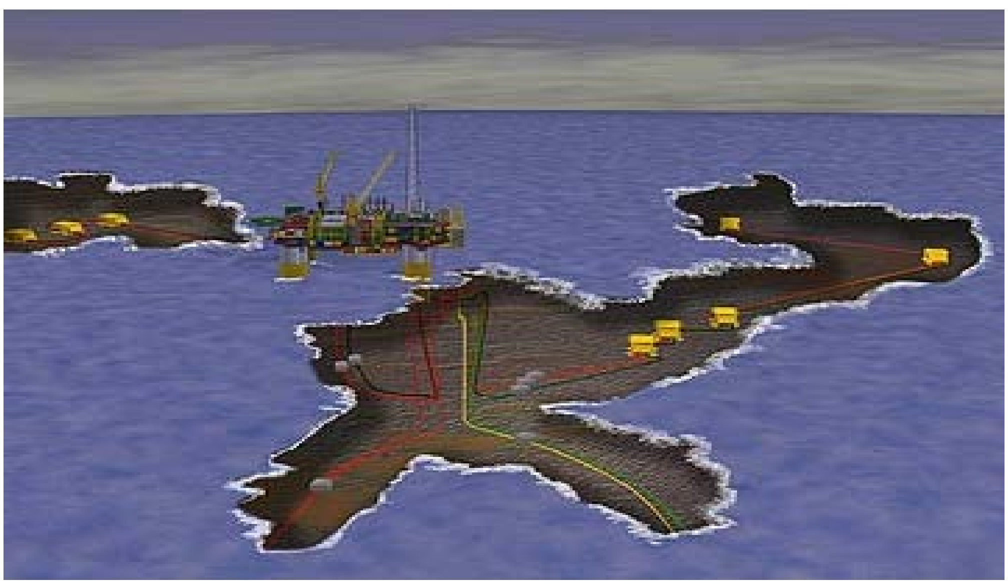


Figure 23 Gjøa's field development (Statoil, 2009)

Development of the field consists of 13 subsea wells connected to four subsea templates and one satellite that tied-back to semi-submersible production platform. Stabilized oil is exported through a dedicated 55-km pipeline to Troll Oil Pipeline II and then to Mongstad oil refinery near Bergen. Rich gas is exported through 130-km pipeline to Far North Liquids and Associated Gas Transport System (FLAGS) in UK continental shelf and then to St. Fergus gas processing terminal in UK. Gjøa platform gets its electricity partly from the shore (from Mongstad oil refinery) and partly from gas power turbine in the platform.

Initially the field was considered economically marginal but it became viable when it was jointly developed with Vega and Vega South fields. The two Vega fields are developed through subsea tied-back to Gjøa platform and treated as two different projects. Nevertheless, in this study analysis of Norwegian value creation is limited to Gjøa field development to streamline the calculation process.

3.1.4.2 Drilling and Well

The field was initially developed with 13 subsea production wells consisting of 4 gas wells and 9 oil wells. Recovery strategy is a pressure depletion strategy where oil production was prioritized in the first couples of years and gas cap blowdown started in 2015. The drilling, according to Statoil, was very complicated and expensive because of challenging structure of the reservoir (Statoil, 2009). Oil column is relatively thin varies between 30 until 45 meters of vertical thickness inside the reservoir. Gas layer is located above oil layer up to 300 meters thickness of gas cap and water lies beneath the oil. Drilling of production wells was commenced in 2009 and continued until 2012 using a semi-submersible drilling rig.

3.1.4.3 Platform Development

Gjøa's platform is a semi-submersible floating production platform. Topside is completed with processing facility, riser module, living quarter, helideck, flare tower, and utility module. Hydrocarbon from well stream is processed in 3-stages processing separator producing oil, gas, and water. Oil and gas are exported to land via pipelines and produced water is further treated before discharge to the sea. There are two inlets in the separator, one for hydrocarbon stream from Gjøa reservoir and the other for stream from Vega fields. Mono-ethylene glycol unit (MEG lines) is installed to supply MEG to a long 32-km flowlines connecting Vega fields with Gjøa platform. MEG injection to Vega's flowline acts as anti-corrosion agent that absorbs salt water, salt crystal, and finest corrosion particles. Platform's living quarter consists of 100 single-beds and made from aluminium. Platform's electrification uses gas power turbine to provide half of the electricity and 100-km power cables is placed on sea bed to provide remainder requirement. The gas turbine is completed with low-NOx burner and a heat-recovering system to reduce the total gas combustion emission. Overall, operating dry weight of the topside is 22000 tonnes.

Table 7 Gjøa offshore processing module facts (Regjeringen, 2007)

	Units	Capacity
Max. Liquids capacity	Sm^3/day	23000
Max. Oil production	Sm^3/day	13800
Max. Gas production	mill. Sm^3/day	17.3
Max. Gas export rate	mill. Sm^3/day	17.3
Max. Oil export rate	Sm^3/day	13800
Max. Produced water treatment	m^3/day	19000
Max. Lift gas injection	mill. Sm^3/day	0.3

Gas export pressure	Bar	160
Oil export pressure	Bar	110
Inlet separator pressure	Bar	65

Platform's substructure features a ring pontoon and four square columns with bilge radii. The hull is permanently moored on the location with a conventional 150 mm chains mooring lines. The hull has operating dry weight about 15700 tonnes. Riser system uses flexible risers to offset the large motions (heave, pitch, and roll motions) of the platform. In total, there are 7 risers (with 16 slots) that consist of 1 gas export riser, 1 oil export riser, 3 well streams riser, and 1 lift gas riser.

3.1.4.4 Subsea System Development

Development of subsea system in Gjøa consists of 4 subsea-templates with 4 slots each and 1 satellite. Three of the templates are positioned within approximately the same distance and connected to 2 gas production wells and 7 oil production wells. One template is a stand-alone structure that located in different position from the other 3 three templates connects to 1 gas well and 2 oil wells. One satellite gas production well is connected to stand-alone template. The four templates are tied-back to Gjøa platform via 10" and 12" flowlines with total length approximately 25 km. In addition to those flowlines, a 6" flowline is installed to inject the gas lift to reservoir. Three static umbilicals, 10.4 km long in total, and 2 dynamic umbilicals with 2 umbilicals jumper are installed as electro-hydraulic-chemical control lines.

3.1.4.5 Pipelines and Cables Development

Export pipelines consist of stabilized oil pipelines and rich gas pipelines. Stabilized oil pipeline is a series of 16" OD steel pipes with total length of 53 km carrying the oil to existing Troll Oil Pipeline II and then to Statoil-operated Mongstad oil refinery. Rich gas pipeline has 28"OD and total length of 130 km carrying the gas to St. Fergus gas terminal via FLAGS trunklines in UK Continental shelf. Gassco takes the operatorship for both pipelines when the production commenced.

Cable is associated with Alternating Current (AC) power cables from land to the Gjøa installation. The 100-km long of cables is fabricated to provide electricity requirement in Gjøa field that is roughly equal to 0.1% of Norway's annual consumption. The decision to supply half of electric power from land is expected to reduce carbon dioxide emission by up to 210000 mt/year compared to conventional solutions and limit the emission of nitrogen oxides and volatile organic compounds as well as reduce platform's weight requirement, fuel consumption and noise level.

The completed system consists of a 98.5 km static submarine AC cable supplying 40 MW power at 115kV and a 1.5 km dynamic cable links the static cable on the sea bed to the platform. The required electric power is supplied by a power station in Mongstad oil facility that can generate reliable supply with minimum environmental impact from both onshore and offshore development work. In its antiquity, Gjøa platform is the first offshore mobile platform that receives electric power from land and its success has pioneered the same approach to other field development in NCS.

3.1.4.6 Norwegian Value Creation in Facilities Development

3.1.4.6.1 Overview

Gjøa facilities development generates a modest Norwegian share at just about 48% of overall field development costs. Platform and subsea system produces a comparatively high Norwegian content, 73% and 60% Norwegian deliveries of their respective development cost, as topside and majority of subsea components were fabricated in Norway and prepared by Norwegian companies. Substructure and power cables, on the other hand, deliver a relatively small Norwegian share of less than 35% of their respective development cost as both components were manufactured in abroad and Norwegian involvement merely came from installation and bulk deliveries. Export pipeline is subsequently the least Norwegian value creator with only 25% Norwegian deliveries is generated from its total investment budget which mainly came from installation process.

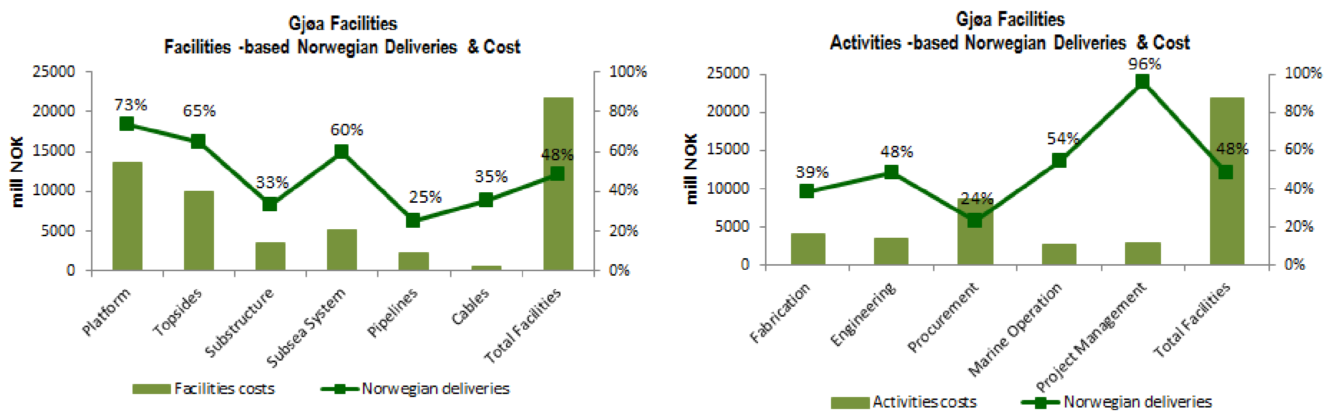


Figure 24 Norwegian Value Creation of Aasta Hansteen's facilities development

From activity point of view, project management generates the largest Norwegian value added where 96% of the activity's budgeted cost returns to Norwegian society. Marine operation produces a moderate Norwegian delivery which mainly came from power cables and subsea system installation. Smaller Norwegian value added is generated by engineering activity where significant engineering hours were executed from Mumbai. Procurement, as normally occurred, delivers a fairly small Norwegian value creation as steels and different kind of equipment were mostly supplied by non-Norwegian suppliers. Fabrication, at the very last, produces a modest Norwegian shares which largely came from topside's and subsea system fabrication in different parts of Norway.

3.1.4.6.2 Topside

Statoil awarded EPCH contract of the topside to Aker Solutions and in addition to this, Aker solutions was also awarded a contract to mating the topside with hull. Detail engineering was headed from Oslo office but significant part of the engineering hours was performed by Aker Solutions team in Mumbai. Fabrication was carried out in several Aker's yard in Norway including in Stord for the main deck and processing module and Egersund for risers module. Aker subcontracted EPC of living quarter and helideck to Apply Leirvik. The fabrication of living quarter took place in Apply's facility in Stord while helideck was built in Singapore and assembled afterwards in Stord. Procurement of flare tower was subcontracted to Kvaerner who built the structure in Verdal.

Procurement of material and equipment were coming from suppliers with Norwegian billing address (local suppliers or Norwegian subsidiaries of foreign companies) and overseas suppliers. Several important suppliers included Dresser-Rand AS who supplied compression equipment and drivers and gas turbine, Kongsberg Maritime who supplied platform's control system and Luster Mekanika Industri AS who supplied pipes and pipes system. The steel requirement was purchased from abroad and equipment's fabrication was also partly performed in abroad. Completion of topside was done in Stord and Aker Marine Construction took responsibility to mate the topside with hull in the fjord outside the yard, assists platform's tow-out to the offshore location, hook-up the platform to the sea bed (install the mooring lines) and commissioning the platform.

Overall, Norwegian value added for EPC and marine installation of topside is estimated at 71% of topside's development cost. The fabrication and offshore installation were pure Norwegian value added. Procurement and engineering creates an approximately 70% Norwegian value added of their respective activity's budget.

3.1.4.6.3 Substructure (Hull)

Statoil awarded EPC contract of the substructure to Samsung Heavy Industry (SHI). Norwegian value added in here is fairly small as workforces and material were mostly procured from outside Norway. Fabrication was utterly a non-Norwegian value creation since it was carried out in SHI yard in Geoje, S. Korea using non-Norwegian workforces. Steel, a large portion of fabrication cost was supplied domestically in Korea hence didn't create any value for Norway but some equipment were purchased from Norwegian suppliers on top of other foreign suppliers. Some of documented suppliers included Luster Mekanika Industri in Norway, STX Europe in Zwezdochka, Russia and Polish companies Promorze, Energomontaz, Morska, and Energop. Transportation of the hull was also non-Norwegian value added where Bermuda-based Dockwise Mighty Servant vessel was hired to execute the task. The hull was transported to water site near Aker's Stord yard where it would be mated afterwards with topside and tow-out to offshore location.

Completed in the substructure are flexible risers and mooring lines. NKT Flexibles in Kalundborg, Denmark supplied the flexible risers and Technip won EPCI contract of gas export smoothbore riser. Technip manufactured the component in Le Trait, France and installed it with its own fleet Skandi Arctic. Skandi Arctic is not a Norwegian registered boat hence the profit for its rental is not a Norwegian value creation. Acergy Stavanger took over the task to install the flexible risers and generate a quite high of Norwegian value added from the crew and equipment utilized in the operation. Mooring chains were fabricated in abroad but mooring equipment including 16 Roller RamWinches and 16 underwater fairleads to pull in and secure the chains were prepared by Aker Kvaerner Pusnes in Arendal and installed by Aker Stord, produces a high Norwegian value added.

Overall, EPC and marine operation of the substructure produce a Norwegian value added of nearly 40% of its development cost. The biggest contributors are offshore operation and engineering with Norwegian shares of around 60% from their respective cost allocation.

3.1.4.6.4 Subsea System

Subsea system development for Gjøa was truly a Norwegian ownership, delivered by several subsea contractors that are registered and own facility in Norway. Technip won the EPCI contracts of flowlines and spools while Subsea 7 got EPCI contracts for PLETs. Aker Subsea was awarded EPC contract for umbilicals and Acergy was responsible for the installation. FMC Technologies scooped EPC of template, manifolds, and subsea Christmas tree where Subsea 7 took care of their offshore installation.

All contractors performed detail engineering in Norway except Subsea 7 who did part of the works in London. All fabrication also took place in Norway (Technip in Orkanger, Aker Subsea in Moss, Subsea 7 in Vigra, and FMC Tech in Kongsberg) except for subsea Christmas tree that was fabricated in FMC facility in Dunfermline, UK. All steels requirement were procured from abroad and nearly half of equipment came from Norwegian suppliers. Technip perform subsea installation with its own fleet and generate less than 40% Norwegian deliveries. Subsea 7 and Acergy also used their own fleets but deliver higher Norwegian contend of almost 70% of the cost allocations.

All in all, EPCI and project management of subsea production system in Gjøa generates Norwegian deliveries at nearly 70% of its investment budgets.

3.1.4.6.5 Export Pipelines and Cables

No Norwegian value creation in engineering, procurement, and fabrication (including coating) of oil and gas export pipelines for Gjøa field. Both pipelines were fabricated by Japanese-owned Mitsui (oil pipeline) and Metal One (gas pipelines) in Japan and coated by Bredero Shaw in Scotland. Rambøl Oil & Gas was engineering partner in the project and executed the task in Denmark.

Pipeline installation was commissioned to Saipem who execute the preparation works from its office in London. Saipem subsequently awarded the contract of transshipment, storage, and load out of 113000 tonnes of steel pipes to Norwegian company NorSea Group. Norwegian value creation by Saipem is very small, less than 30% of marine operation cost allocation and mainly came from activities by NorSea. Another Norwegian value added in offshore installation came from rock dumping activity. Dutch firm carried out the activity with their own vessel and equipment but the rocks were procured locally. Overall, EPCI of oil and gas export pipelines in Gjøa field is estimated at 11% of pipeline’s development cost.

EPCI of power cables was managed by ABB. Norwegian value creation in here comes from installation activity where ABB subcontracted the works to Ocean Team. Ocean team has Norwegian billing address but equipment were supplied from their equipment-base in Netherland reduce Norwegian deliveries in installation activity. In total, Norwegian value added for EPCI of power cables is estimated at 22% of its investment spending.

3.2 Evaluation of Drilling and Well Completion

3.2.1 Drilling and Well Completion Service Operation in Norwegian Continental Shelf

Offshore drilling in NCS is a highly specialized and technology driven business. It possesses high technological innovation and safety procedures to meet more challenging drilling requirement and strict safety obligations from E&P companies and Norwegian authorities. In NCS both Norwegian and International companies are actively involved in drilling rig market. Seadrill, Maersk Drilling, and Transocean are currently the biggest international players whereas Odfjell Drilling is the renowned local player. Whether the rigs are owned by International or Norwegian drilling companies, it is a common practice for rigs that operated in NCS to be fully legally, for tax purpose, registered in a country with low or no corporate tax, for example in Bermuda or Panama Islands (Agenda Kaupang, 2015). This way, corporate taxes from operating income by the rig's owner will flow out of Norway and delivers no Norwegian value added to the country.

Drilling and completion costs make up a total capital expenditure for well development (i.e. well cost). The two costs are essentially a function of time and share a same component, rig rate, in addition to operating expenditures specific to drilling and completion activities. The following equation is usually used to calculate the well cost.

- ❖ Well cost = engineering cost + drilling cost + completion cost
- ❖ Drilling cost = (rig rate + drilling service rate) x no. of drilling days*
- ❖ Completion cost = (rig rate + completion service rate) x no. of completion days*

*Number of drilling and completion days is greatly affected by number of wells, type of well (dry tree or wet tree), type of rig, type of completion intervention (heavy/medium/light) and reservoir depth. More number of wells, more reservoir depth, wet tree wells, and heavy intervention consume more time in drilling and completion than the other way around.

Engineering cost belongs to cost of engineering performed by E&P companies. Rig rate comprises all costs related to operation of the rig which include capital lease cost and cost of rig's crew[7]. Drilling service rate covers all cost related to drilling operation other than cost of rig that include consumables (drilling mud, additives, cement); Oil Country Tubular Goods-OCTG (casing, conductors, and tubing); other drilling equipment and accessories (pump, motor, vibrating hose and etc); Third party maintenance equipment and crew; logistic services (supply base, helicopter service, and catering); and drilling crew from E&P companies. Completion

[7] Rig cost = lease cost + cost of rig's crew belongs to the crew from drilling company (not the crew from operator)

service rate covers the similar cost entity with drilling service rate however the service is provided by specific well service companies.

Consumables generate a moderate Norwegian share where the ingredients are partly imported but mixing process takes part in Norway. The big players in consumables including M-I-Swaco Norge from Schlumberger and Statoil Fuel & Retail. OCTG pipes are produced in abroad and mostly come to Norway through Norwegian subsidiaries of foreign suppliers most notably Tenaris, Sumitomo, and Archer. Norwegian value creation in OCTG is not significant and simply come from storage and distribution activities which usually handled by Norwegian logistic providers. Logistic services for drilling and completion are pure Norwegian value creation. Local and foreign suppliers supply different kind of drilling equipment which fabrication is partly performed in Norway and large amount of equipment's components is imported. Maintenance service for the drilling rig is essentially a responsibility of rig's owner and thus has been covered in rig rate however third party maintenance are often times needed. This third party maintenance is hired by operator and usually a Norway-based maintenance companies.

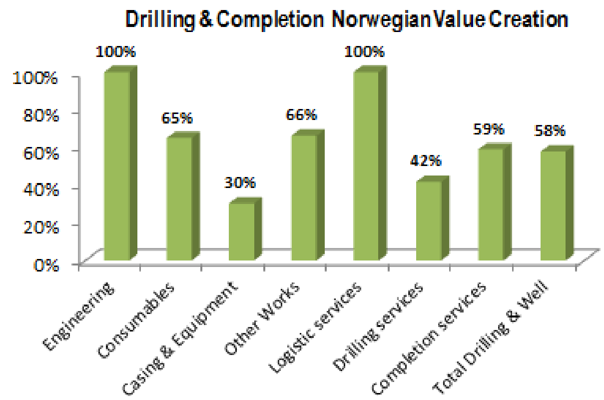
Completion works or in general well service in NCS is dominated by international players most notably Schlumberger, Halliburton, Baker Hughes, and Weatherford (the big four) (Agenda Kaupang, 2015). All of them are headquartered in Houston, USA but have major organizations and facilities in Norway. Norway's offices are situated in Stavanger city with equipment facility spread in several parts of Norway (mostly Stavanger). Engineering and design are pure Norwegian value creation as the activity is usually performed in Norway and uses Norwegian personnel. Procurement of materials and equipment, however, is mostly coming from abroad except for Weatherford that also produce different kind of equipment in Norway makes Norwegian value added by Weatherford is bigger than the other three. Even so, an overall of relatively small Norwegian content are expected from equipment deliveries.

Completion works are normally performed by Norwegian crew from well service companies (in addition to works by rig's crew) and generates a relatively high Norwegian delivery. However, installation work of wellhead and Christmas tree are treated different between dry-tree wells and wet-tree wells. For dry-tree wells wellhead and Christmas tree installation can be considered as part of completion work by well service company while in case of wet-tree wells the operation is usually treated as part of subsea system installation by subsea contractors (Agenda Kaupang, 2015). Other works by smaller companies with different well completion expertise generates a comparatively high Norwegian value added as many of Norwegian firms capable to deliver this service. Among those are DeepWell AS who provides wireline services and Roxar AS who provides reservoir management software.

Refer to (Agenda Kaupang, 2015), as of autumn 2014 rig cost constitutes about 38%-43% of total well cost for jack-up rig and 40%-44% for semi-submersible rig. The rest are belongs to drilling and completion service cost which around 57%-62% for jack-up rig and 56%-60% for semi-submersible rig. Rig cost (cost of capital lease and rig's crew) is considered to create no Norwegian value added since the rig is not registered in Norway hence all operating income tax is flown out of the country. Drilling and completion service costs, however, create value to Norway since Norwegian suppliers heavily involve in delivering the services.

In most cases, drilling and completion service rates are fairly fixed but rig rate is influenced by the demand level of the rig (Agenda Kaupang, 2015). When demand from market is high rig's owner has more power to set higher rig rate in order to generate more income. This income is used to cover capital expenditures of fabricating the rig and provide more profit to rig's owner. When demand is low rig's rate is likely to decline in order for rig's owners to keep rig's capacity filled and generate positive cash flow. Demand of drilling rig is strongly influenced by oil price. In the case of oil price slump demand of drilling rig tends to decline as E&P companies trying to cut company's cost by reducing drilling activities which eventually lead to lower rig's rate. Since essentially no Norwegian deliveries is generated from the rig cost and drilling and completion services costs are relatively fixed, when the rig rate is going down then the overall Norwegian deliveries created by drilling and well completion increases in percentage. According to (Agenda Kaupang, 2015), 20% reduction in rig rate increases overall Norwegian shares in drilling and well completion by around 8%.

3.2.2 Norwegian Value Creation in Drilling and Well Completion



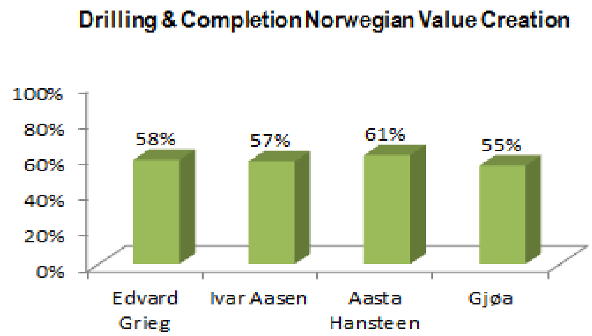


Figure 25 Norwegian Value Creation of drilling & completion

Figure 25 portrays Norwegian value creation of drilling & completion in the four fields in analysis. The right-hand chart represents summary of Norwegian deliveries for individual field and left-hand chart represents average Norwegian deliveries for each activity performed in drilling & completion. In summary, Norwegian deliveries of drilling and well completion among the 4 fields are comparable at a range of 55%-61% of respective field well development cost. The comparable result is achieved because supply arrangements in drilling activities are practically the same between different fields and ultimately similar suppliers are utilized by different projects. Discrepancy occurs mainly because of variance in rig rental cost and only in a term of percentages not by total value.

Table 8 Norwegian value creation of drilling & completion (Detail Activity & Fields)

Drilling & Completion	Engineering	Consumables	Casing & Equipment	Other Works	Logistic services	Drilling services	Completion services	Total Drilling & Well
Edvard Grieg	100%	65%	36%	70%	100%	40%	55%	58%
Ivar Aasen	100%	65%	30%	64%	100%	38%	62%	57%
Aasta Hansteen	100%	65%	35%	68%	100%	54%	65%	61%
Gjøa	100%	65%	21%	63%	100%	35%	55%	55%
Total Drilling & Well	100%	65%	30%	66%	100%	42%	59%	58%

For individual field, well design and engineering is considered a 100% Norwegian delivery as every operator carried out the works with their in-house engineering team. Rig's owners and service companies also perform their own engineering but the activity is typically counted in drilling & completion service rates. Drilling service delivers a modest Norwegian content at average 48% of overall well cost (i.e. drilling cost + completion cost). Edvard Grieg and Ivar Aasen use jack-up rig from Rowan Companies and Maersk Drilling to drill the development wells. Aasta Hansteen will use semi-submersible rig but the decision about the rig's owner hasn't final yet. Gjøa, similar to Aasta Hansteen, also used semi-submersible rig and lease it from Transocean.

Aasta Hansteen is estimated to generate higher Norwegian deliveries in drilling and well completion as drilling campaign is likely to occur in the midst of low oil price. As discussed in previous section, low oil price increases percentage of Norwegian value creation in drilling & well completion as the rig rate is likely to go down caused by declining demand (Agenda Kaupang, 2015). No information so far about the starting time of drilling however as of June 2016 Statoil is still in the market to find a rig drill. Figure 26 shows the declining trend of rig's day rate in the past 3 years for Europe's jack up rigs and global semi-submersible rigs. The declining trend is aligned with the recent oil price crisis (Figure 27) which is expected to continue for the next couple of years despite great uncertainty and volatility along the way.

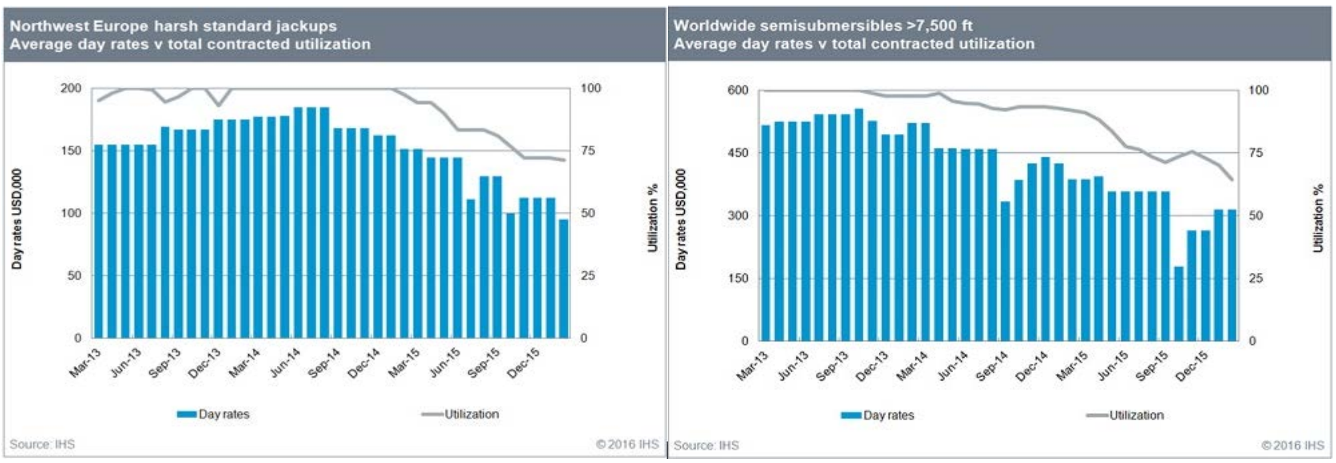


Figure 26 Average day rate history & utilization for jack-up and semi-submersible drilling rig (IHS, 2016)

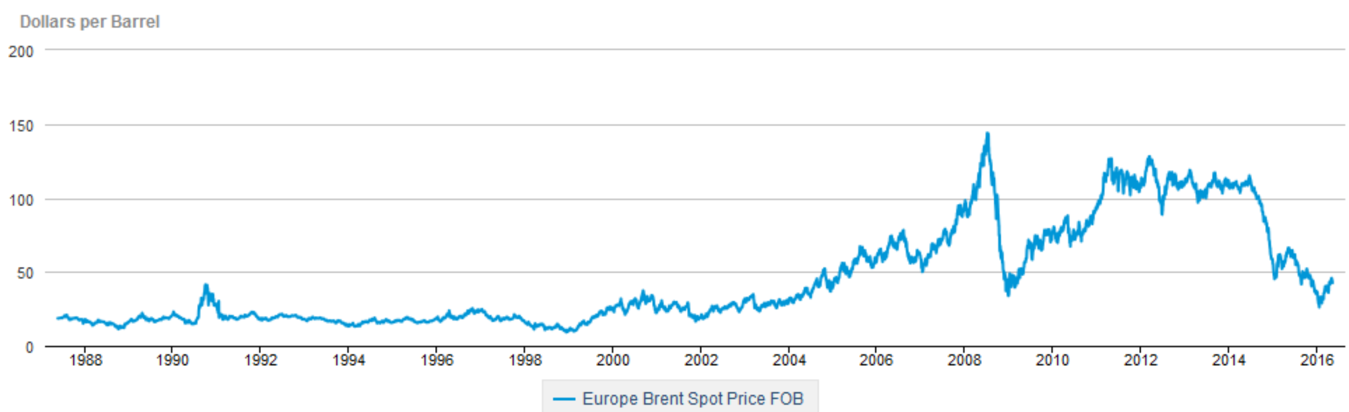


Figure 27 Europe Brent spot price (Dollars per barrel) (U.S. Energy Information Administration, 2016)

Both Ivar Aasen and Gjøa contract Schlumberger to provide well services but no information so far for Edvard Grieg and Aasta Hansteen. Edvard Grieg, Consumables (mud, chemicals, additives, etc) are mostly procured from M-I-Swaco Norge AS and Statoil Fuel & Retail create a comparable Norwegian delivery at around 65% of overall consumables spending. In producing drilling consumables, M-I-Swaco Norge imports majority of the materials and mixing them in facility in Norway.

OCTG (Casing/tubing/conductors) and drilling equipment are mainly supplied by suppliers with Norwegian billing address (local suppliers or Norwegian subsidiaries of international companies) but fabrication and procurement of many component are largely performed in abroad make the Norwegian value added in here are relatively small at about 30% of drilling & well capital spending. No detail information on OCTG suppliers for the four fields but several recorded suppliers for drilling equipment are including Tenaris (seal connections for Edvard Grieg), Score Group Plc and Ellingsen (valves system), Eureka Pumps AS and PG Pump Solutions (rotary pumps) and National Oilwell Varco (variety of drilling machineries and accessories).

Helicopter service, caterer, and supply base are pure Norwegian deliveries where daily operations use local people and domestic commodities. Asco Norge AS is a supply base provider for Edvard Grieg, Ivar Aasen and Aasta Hansteen whereas Fjørd Base AS serves Gjøa. Asco uses an existing supply base in Tananger for Edvard Grieg and Ivar Aasen and a new base in Sandnessjøen for Aasta Hansteen while Fjørd Base uses its supply base in Fløro for Gjøa. Gjøa and Aasta Hansteen awarded helicopter service CHC Helicopter while Edvard Grieg and Ivar Aasen use Bristow Norway Helicopter AS.

4 Discussions

This thesis examines Norwegian value creation in four different development projects. Each project was characterized by development of a new stand-alone platform. While in actuality field development can also be a subsea tie-back (i.e. satellite project), this thesis focuses on the analysis of Norwegian deliveries in stand-alone project. For tie-back projects development cost will vary from case to case, depends on the element of host platform modification, but deliveries by Norwegian companies is fairly similar and close to 100% for all cases due to strong Norwegian ownership in subsea development. The stand-alone projects, however, represent more combination of local and global contents generate variation of Norwegian deliveries between the projects. That way, broader analysis regarding the topic of this thesis “Norwegian value creation in development of offshore oil and gas fields” can be carried out and additional key information can be obtained.

4.1 Anaysis of Norwegian Value Creation among the Four Projects

For the four projects in analysis summary of some important information related to field development is presented in Table 9. Estimation of Norwegian value creation is subsequently performed with that information and other relevant data and presented in Figure 28.

Table 9 Summary of important information of the four fields in analysis

Field	Topside		Substructure		Subsea System		Export Pipelines		Cables		Drilling Rig	
	Location	Contractor	Location	Contractor	Location	Contractor	Location	Contractor	Location	Contractor	Flagship	Contractor
Edvard Grieg	Norway	Kvaerner	Norway	Kvaerner	N/A	N/A	India/Scotland	Welspun/Bredero	N/A	N/A	Marshall Island	Rowan
Ivar Aasen	Singapore	Sembcorp	Italy	Saipem	N/A	N/A	Norway	EMAS AMC	Sweden	ABB	Singapore	Maersk
Aasta Hansteen	S.Korea	Hyundai	S.Korea	Hyundai	Norway	Subsea 7/Aker	Japan/Malaysia	JFE&Itochu/Wasco	England	Deep Ocean	N/A	N/A
Gjøa	Norway	Aker Solutions	S.Korea	Samsung	Norway	FMC/Technip	Japan/Scotland	Mitsui&Metal One/Bredero	Sweden	ABB	Marshall Island	Transocean

From Figure 28 it is understood for facilities development Edvard Grieg project delivers the biggest Norwegian value added and followed by Gjøa, Aasta Hansteen and Ivar Aasen. As for drilling and completion the four projects have comparable Norwegian deliveries. From here a new diagram as presented in Figure 29 is used to establish the analysis.

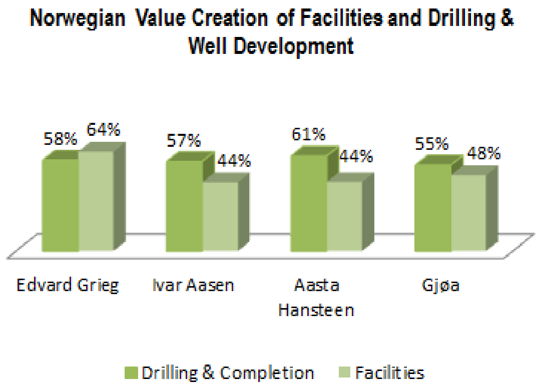


Figure 28 Summary of Norwegian Value Creation of the four fields in analysis

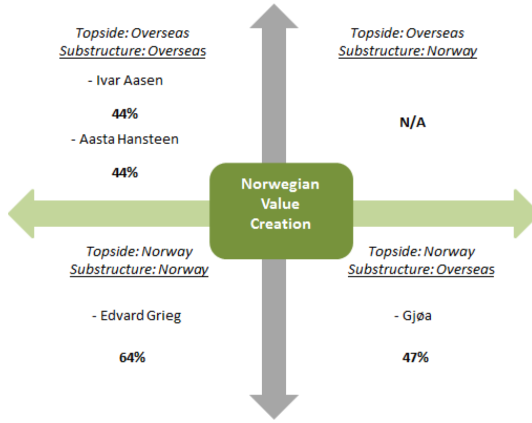


Figure 29 Mapping of Norwegian Value Creation of the four fields in analysis

Figure 29 suggests the mapping of Norwegian value creation based on the fabrication location of platform's topside and substructure. Here, Edvard Grieg project which both topside and substructure built in Norway gives the highest Norwegian value added estimated at 64% of facilities development cost. Gjøa which topside built in Norway but substructure built in South Korea delivers an estimate of 48% Norwegian shares. Ivar Aasen and Aasta Hansteen which both topside and substructure built in abroad generate Norwegian shares estimated at 44% of their respective facilities development cost.

The result of this mapping is not remotely surprising. Facilities-based cost evaluation shows that topside development contributes about 40% of field development costs (see Table 10) and activities-based costs evaluation shows that procurement and construction constitute more than 60% of topside development cost (see Table 11). From the two evaluations it can be concluded that fabrication and procurement activities related to topside development are the major cost contributors and value creators in field development project. As a consequence, location of topside fabrication and origin of goods and services used in topside fabrication are particularly important in increasing value creation.

For Norway, if the country wants to maximize Norwegian value creation in the development project then topside fabrication ought to be performed in Norway and supply of goods and services for topside development ought to be dominated by Norwegian suppliers. In this thesis, both Edvard Grieg and Gjøa had topside fabrication in Norway hence generate the two largest Norwegian value added among the 4 fields. However since Edvard Grieg substructure was also fabricated in Norway Norwegian deliveries for this field is eventually higher for approximately 13% additional value added was delivered by Norwegian companies.

Table 10 Facilities-based cost evaluation of the four fields in analysis

Field	Cost (mill NOK)						Total Cost (mill NOK)
	Topside	Substructure	SPS	Pipelines	Cables	Platform	
Edvard Grieg	15498	3657	0	2596	0	19155	21751
Ivar Aasen	10234	2554	2841	429	159	12788	16218
Aasta Hansteen	13139	6872	5945	14390*	1644	20011	41990
Gjoa	10557	3064	5182	2344	650	13621	21797
Total	49428	16147	13969	19759	2453	65576	101756
Proportion to Facilities Cost	49%	16%	14%	19%	2%	64%	100%
Proportion to Field Cost	40%	13%	11%	16%	2%	53%	83%

*Polarled gas pipeline

Table 11 Topside/substructure development cost proportion

Activity	Cost (mill NOK)					Total Cost (mill NOK)
	Engineering	Procurement	Construction	Marine Operation	Project Management	
Platform development	12621	22994	16363	4900	8697	65576
Proportion	19%	35%	25%	7%	13%	100%
Topside development	10575	17924	12412	1949	6568	49428
Proportion	21%	36%	25%	4%	13%	100%
Substructure development	1917	4941	3821	2821	2647	16147
Proportion	12%	31%	24%	17%	16%	100%

In topside fabrication, workforce is one of the two biggest cost entities and value creator other than steel (Jenssen, Knudsen, Ovesen, & Sørnes, 2015). In any countries fabrication is carried out workforces to build the structure would certainly come from the country's labor market. If fabrication is performed in Norway then Norwegian people are used as workforces and income tax generated during construction periods will go back to Norwegian society delivers significant value for Norwegian society. In addition, domestic fabrication means more opportunities are created for local suppliers to take parts in fabrication process create larger ripples effect to society. The ripples effect reaches not only Norwegian equipment suppliers and other technical contractors but extents to general services such as transportation, hospitality (accommodation and catering), warehousing, and other supporting services. The accumulated ripple effects would be definitely larger compared to foreign fabrication.

When fabrication is performed in abroad Norwegian value creation remains present, especially from equipment and bulk deliveries. The role of E&P companies (project owners) in here is significant as they own an authority to set Norwegian content policy in procurement activity. E&P companies can nominate relevant Norwegian suppliers or purchases the equipment by themselves or require EPC(I) contractors to procure certain values of equipment from suppliers with Norwegian billing address. Oftentimes Norwegian suppliers also selected by EPC(I) contractors because of their superior competencies and qualities and ability to meet very strict industry standards (NORSOK). At the end, all those procurement "enforcements" not only ensure Norwegian involvement in every petroleum project but eventually develop national services industry into global competitiveness of Norway.

Nevertheless, the benefit that Norwegian suppliers gain in here is not without consequences. To become more responsive to clients' requests and maintain international competitiveness

Norwegian suppliers might necessary to streamline their supply chain by putting new and/or additional production facilities outside Norway, preferably near clients' locations or in countries with cheaper labor and/or raw material costs (Bang & Markeset, 2012). Suppliers will retain product's core competencies and technologies in Norway but manufacturing is performed in abroad. This way, Norwegian suppliers can offer shorter delivery lead times (especially for time-critical products such as valves and pressure tanks) and lower-priced products. This typical business arrangement eventually diminishes accumulation of Norwegian value creation in procurement activity as some major tasks were performed with less or no Norwegian involvement.

4.2 Analysis of Norwegian Competitiveness in Offshore Production Platform Development

While Norway has successfully developed its national clusters of oil and gas suppliers, including cluster of platform production, the recent statistic shows that in the course of 15 years fabrication of stand-alone facilities are dominated by foreign yards. To discuss more about it a total of 20 fields development projects are examined. The 20 fields have their PDO approved between 2000 and 2015 and use stand-alone facilities as development solutions. The stand-alone facilities consist of fixed and floating production platform, unmanned wellhead platform aned jack-up production rig. For the 20 fields in analysis a total of 50 structures are identified which include topside, substructure, and individual topside's module that built separately from the main structure. Finally, the fabrication locations for each of the structure are identified to elaborate the analysis.

As shown in Figure 30, from the total 50 structures in evaluation 27 structures were fabricated in overseas, mainly in South Korea, and another 23 were built in Norway. Of the 4 projects analyzed in this study 3 projects also recorded to have platform fabrications in abroad (see Table 9). Further evaluation in Figure 31 subsequently reveals that construction by foreign yards was mostly occurred between 2004 and 2014 while local fabrication was heavily concentrated from 2000 to 2003 and 2015 shared the same proportion for both local and foreign yards. A question therefore appears: why foreign yards did very well in 2004-2014 but very inferior in early 2000s? Or similarly, why Norwegian yards fail to dominate competition in 2004-2014 but incredibly good in 2000-2003? The following explanations might have the answers for those two comparable questions.

Figure 30 Countries of location for stand-alone facilities development between 2000 and 2015(Various sources)

Figure 31 Distribution of countries location for stand-alone facilities development by period (Various sources)

Norwegian krone (NOK) exchange rates influence Norway's economy in many ways. According to Norges Bank there are four variables that influence Norwegian krone exchange rate: oil price, price differential between Norway and other countries, international financial turbulence and interest rate differential against other countries (Norges Bank, 2000). The first two variables tend to influence krone exchange rates in the long run while the other two affects short-term performances. Norges Bank subsequently defines that a sustained rise in oil price leads to an appreciation of krone while an increase in price level in Norway leads to depreciation of krone. The measurement of krone exchange rate depends on the currency against which the krone is measured. For instances, krone may appreciates against dollar but at the same time depreciates against euro. In this discussion, the US Dollar (USD) is selected as the currency of reference as many international currencies pegged their exchange rates to USD and use it in international trade transactions.

The exchange rate between Norwegian krone and US Dollar (NOK/USD) is particularly important in determining procurement strategy of a platform as platform fabrication involves substantial flows of goods and services from international markets. If the exchange rate of Norwegian krone to USD is in equilibrium point and fairly stable, which for so many years falls around 6 NOK/USD, competitiveness of foreign fabrication increases as they generally offer lower cost of steel plates (Wijnolst & Wergeland, 2009), lower cost of labor (International Monetary Fund, 2013) and increasing competence in high-value products (OECD, 2015). However, if exchange rate of Norwegian krone to USD is depreciated in a long run such that the rate rises to more than 7 NOK/USD, competitiveness of local fabrication increases as imports of goods and services become more expensive due to additional krone required to pay the transaction. In this case, higher cost to import (i.e. higher cost of imported material) increases the selling power of domestic suppliers and enhances Norwegian yards competitiveness over foreign competitors. Figure 31 and 32 provide evidence of how krone exchange rates to USD influence competitiveness of local fabrication.

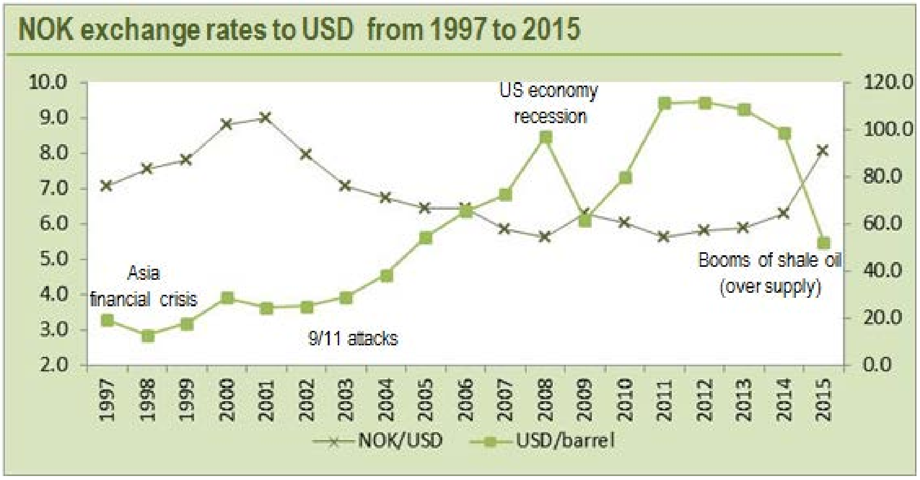


Figure 32 Exchange rates of NOK to USD and Brent crude oil prices from 1997 to 2015 (Norges Bank, 2016; U.S. Energy Information Administration, 2016)

A series of Asia financial crisis in 1997/1998 and 9/11 attacks in 2001 had dropped global oil price from 1997 to 2002 and consequently weakened Norwegian krone. Krone was depreciated from around 6 NOK/USD in early 1997 to more than 8 NOK/USD in 2001. The weaker krone was sustained until early 2003 as oil prices continued to fluctuate after the crises. During this period or particularly from 2000 to 2003 Norwegian yards were dominating national competition for platform's fabrication as 9 out of 10 platform's EPC contracts were awarded to them. Following Irak War in early 2003 oil prices soared rapidly and krone was bounced back to level 6 NOK/USD and stayed performing until 2014 though a slight dip occurred in 2008/2009 when oil prices dropped amid US economy recession. In this period (2004-2014) Norwegian yards were collectively losing the competition to foreign competitors as 21 out of 28 EPC contracts were awarded to foreign yards. Among these were EPC contracts for 3 platform's developments that are discussed in this study: Aasta Hansteen, Ivar Aasen, and Gjøa platforms.

In 2015, oil prices encountered another steep fall and Norwegian krone was tumbled sharply to more than 8 NOK/USD, a 13-year low against dollar. A more than 50% fall in oil price since June 2014 has eventually put Norwegian economy in a downturn and led national petroleum industry in a crisis. However, despite all the pessimistic situations Norway authorities keep committed to develop Norwegian petroleum industry and recently agreed to develop one of the biggest oil discoveries in NCS, Johan Svedrup. Johan Svedrup field development has awarded several major contracts including contract for EPCI platforms. Johan Svedrup will be developed with 4-bridge-linked-steel jacket platforms consisting of processing platform, utility and accommodation platform, wellhead platform, and riser platform. As anticipated contracts for platforms developments are mostly won by Norwegian yards demonstrates the increasing Norwegian competitiveness over foreign competitors in the midst of weakening krone. In Johan Svedrup case, a total of 7 structures (out of 12) including 3 topsides, 3 steel jackets, and 1 living quarter are fabricated in Norway while the rests are built in Poland, Thailand, and South Korea.

In conclusion, relationship between krone exchange rates and competitiveness of domestic fabrication is not straight-forward. By all means, it is not always the case that weaker krone secures the fabrication by local yards. There are indeed many other factors that affects the choice of location. However, krone exchange rates do have influences in increasing competitiveness of local fabrication and consequently in improving the likelihood of local yards to win over foreign rivals.

5 Conclusion

For facilities development, comparison between individual fields concludes that Edvard Grieg generates the highest percentage deliveries by Norwegian companies estimated at 64% of facilities development cost and followed by Gjøa with 48% Norwegian deliveries and Aasta Hansteen (including Polarled gas pipeline) and Ivar Aasen with 44% Norwegian deliveries of respective field facilities development budgets.

Cost evaluation shows topside development contributes about 40% of field development cost whereas fabrication and procurement activities constitute more than 60% of topside cost. It means fabrication and procurement activities related to topside development are the major value contributors in development project. Consequently, Norwegian value creation is particularly affected by location of topside fabrication and origin of goods and services used in topside development. When topside is fabricated in Norway, Norwegian value creation will be greater as fabrication will utilize Norwegian workforces and supply of material/equipment would likely to be dominated by Norwegian suppliers (i.e. suppliers with Norwegian billing address), just like the case of Edvard Grieg.

While Norway has successfully developed national oilfield services industry and eventually becomes a world leader in subsea technology, competitiveness of local fabrication for offshore platform is facing great challenge from foreign rivals. Evaluation of 20 field development projects with PDO approval between 2000 and 2015 indicates that Norwegian krone exchange rates to US Dollar (NOK/USD) influence the competitiveness of local fabrication. The analysis concludes that competitiveness of local fabrication increases when krone depreciates against US Dollar as it becomes more expensive to import goods and services from abroad. Higher cost of imported material increases the selling power of domestic suppliers and enhances Norwegian yards competitiveness over foreign competitors.

For drilling and well completion, comparison between individual fields concludes that the 4 fields in analysis share comparable Norwegian deliveries at a range of 55%-61% of respective field well development cost. The comparable result is achieved because supply arrangements in drilling activities are practically the same between different fields and similar suppliers are eventually utilized by different projects. Discrepancy is mainly occurred because of variance in rig rental cost and only in a term of percentages not by total value.

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Appendices

A. General Formula for Estimating Development Cost

The formulas are cited from Module 19 "Cost and Cost Estimating" OFF515 Offshore Field Development by Professor Jonas Odland, Department of Mechanical and Structural Engineering and Materials Science, University of Stavanger.

A.1. Engineering, hook-up and commissioning, and management costs

$$Cost_{Engineering} = p \times r \times W$$

$$Cost_{Hook-up\ and\ commissioning} = p \times r \times W$$

$$Cost_{Management} = p \times r \times W$$

Where:

p = productivity number: number of man-hours per tonne (MHR/tonne)
r = man-hour rate (NOK/MHR)
W = total weight (tonnes) = equipment weight + bulk weight + steel weight

- Engineering cost: productivity *p* depends on engineering location (regional practice) and complexity of facility. Man-hour rate *r* depends on location of engineering activity.
- Hook-up and commissioning costs: productivity *p* depends on location of activity and complexity of facility. Man-hour rate *r* depends on location of activity and whether the work is done inshore or offshore.
- Management cost: productivity *p* depends on project organization and management philosophy, location of site (s) and complexity of facility. Man-hour rate *r* depends on location of project team.

A.2. Procurement cost (cost of materials)

$$Cost_{materials} = \sum (c_i \times W_i)$$

Where:

W_i = weight for weight category i (tonnes)
c_i = cost per tonne for weight category i including freight (NOK/tonne)
i = weight category (in ACES there are 9 categories which include equipment, electrical, HVAC, instrument/telecom, piping, surface protection/fire proofing, safety and loss prevention, architectural, and structural steel/aluminium).

For bulk materials and steels it is necessary to include a contingency percentage for waste (usually 5% - 10%).

A.3. Fabrication cost

$$Cost_{Fabrication} = \sum (p_i \times r_i \times W_i)$$

Where:

p_i = productivity number: number of man-hours per tonne (MHR/tonne)
r = man-hour rate (NOK/MHR)
W = weight for weight category i (tonnes)

The productivity p_i depends on weight category *i* and location (regional practice). The man-hour rate depends on location of fabrication. In general the same man-hour rate is used for all weight categories at the same fabrication location.

A.4. Marine operations cost

$$Cost_{Marine\ Operations} = \sum (d_i \times T_i)$$

Where:

T_i = time needed for operation i (days)
d_i = overall day-rate for operation i (NOK/day)
i = operation category

The day-rate d_i depends on type of vessel needed for the operation. In general day-rate correlates with oil price. High oil price means high day-rates. The day-rate has to be paid for a certain number of days *T*.

$$T = (T_{\frac{m}{d}} + T_{wow} + T_{operation})$$

Where:

$T_{m/d}$ = time for mobilization and de-mobilization of vessel (days)
T_{wow} = time for wating-on-weather or non-productive time (days)
$T_{operation}$ = time for operation execution, based on expected efficiency (days). For pipelines installation $T_{operation}$ is defined as

$$T_{operation\ for\ pipelines} = (L/R + T_{tie-ins})$$

Where:

L = length of pipeline (meter)
R = lay-rate (meter/day)
$T_{tie-ins}$ = time required for tie-ins operation (days)

- $T_{m/d}$ depends on the location and includes time to get approval from authorities

- T_{wow} depends on environmental conditions for the relevant condition and season and on the characteristic of the vessel
- $T_{operation}$ depends on type of operation and characteristic of the vessel. Normally an expensive vessel can complete the operation faster than cheaper vessel.

B. Overall Cost Estimation Result by ACES

B.1 Edvard Grieg

CAPEX FACILITIES OVERVIEW										mill.NOK
Cost element	Engineering	Procurement	Construction	SUM EPC	Marine op	SUM EPCI	Management	Base estimate	Contingency	Total
Topsides	3170	4448	4116	11734	88	11822	1655	13477	2022	15498
Substructure incl conductors/risers	291	488	531	1310	315	1624	227	1852	278	2130
Piles, anchors and mooring lines	0	196	0	196	316	512	72	583	87	671
Sum Platform	*3461*	*5131*	*4647*	*13239*	*718*	*13958*	*1954*	*15912*	*2387*	*18298*
Subsea/WHP production equipment	0	0	0	0	0	0	0	0	0	0
Flowlines and spools	9	25	0	35	88	122	17	139	21	160
Structures (RB, PLET, PLEM, T, Y)	54	152	0	207	119	326	46	372	56	428
Risers for flowlines/pipelines	75	15	16	107	98	205	29	234	35	269
Umbilicals with risers	0	0	0	0	0	0	0	0	0	0
Sum Subsea	*139*	*193*	*16*	*348*	*305*	*654*	*91*	*745*	*112*	*857*
Export pipelines	42	553	144	740	1158	1898	266	2163	433	2596
Power cables wih risers	0	0	0	0	0	0	0	0	0	0
SUM Facilities	*3642*	*5878*	*4807*	*14327*	*2182*	*16509*	*2311*	*18820*	*2931*	*21751*
CAPEX WELLS OVERVIEW							**days per well**	**days**		**mill.NOK**
Drilling							*34*	510		2608
Completion							*20*	305		1714
Drilling and completion							*54*	815		4322

B.2 Ivar Aasen

CAPEX FACILITIES OVERVIEW										mill.NOK
Cost element	Engineering	Procurement	Construction	SUM EPC	Marine op	SUM EPCI	Management	Base estimate	Contingency	Total
Topsides	1728	3696	2171	7596	210	7806	1093	8899	1335	10234
Substructure incl conductors/risers	270	446	474	1191	289	1480	207	1687	253	1940
Piles, anchors and mooring lines	0	171	0	171	298	469	66	534	80	614
Sum Platform	*1999*	*4313*	*2646*	*8958*	*797*	*9755*	*1366*	*11120*	*1668*	*12788*
Subsea/WHP production equipment	60	388	12	459	60	519	73	592	89	681
Flowlines and spools	39	357	193	589	341	930	130	1060	159	1219
Structures (RB, PLET, PLEM, T, Y)	55	154	0	209	138	347	49	395	59	455
Risers for flowlines/pipelines	23	8	5	37	38	75	11	86	13	99
Umbilicals with risers	44	153	32	229	67	296	41	337	51	387
Sum Subsea	*221*	*1060*	*242*	*1523*	*644*	*2167*	*303*	*2470*	*371*	*2841*
Export pipelines	16	137	37	190	137	327	46	373	56	429
Power cables wih risers	10	57	1	68	54	122	17	139	21	159
SUM Facilities	*2246*	*5567*	*2925*	*10739*	*1632*	*12371*	*1732*	*14103*	*2115*	*16218*
CAPEX WELLS OVERVIEW							**days per well**	**days**		**mill.NOK**
Drilling							*64*	959		4967
Completion							*31*	461		2656
Drilling and completion							*95*	1420		7623

B.3 Aasta Hansteen

CAPEX FACILITIES OVERVIEW										**mill.NOK**
Cost element	Engineering	Procurement	Construction	SUM EPC	Marine op	SUM EPCI	Management	Base estimate	Contingency	Total
Topsides	2338	4742	2663	9743	279	10022	1403	11425	1714	13139
Substructure incl conductors/risers	655	1797	1601	4052	430	4482	627	5109	766	5876
Piles, anchors and mooring lines	0	549	0	549	211	760	106	866	130	996
Sum Platform	*2993*	*7087*	*4264*	*14344*	*920*	*15264*	*2137*	*17401*	*2610*	*20011*
Subsea/WHP production equipment	194	1244	54	1492	135	1626	228	1854	278	2132
Flowlines and spools	29	102	195	327	270	597	84	680	102	782
Structures (RB, PLET, PLEM, T, Y)	99	272	0	371	125	495	69	565	85	650
Risers for flowlines/pipelines	179	936	118	1233	84	1316	184	1501	225	1726
Umbilicals with risers	77	274	38	388	112	500	70	570	86	656
Sum Subsea	*578*	*2827*	*405*	*3810*	*725*	*4535*	*635*	*5170*	*775*	*5945*
Export pipelines	113	5020	911	6044	4933	10977	1537	12513	1877	14390
Power cables wih risers	101	816	11	928	325	1254	176	1429	214	1644
SUM Facilities	*3785*	*15751*	*5591*	*25126*	*6903*	*32029*	*4484*	*36513*	*5477*	*41990*
CAPEX WELLS OVERVIEW							**days per well**	**days**		**mill.NOK**
Drilling							*39*	273		1823
Completion							*41*	289		2013
Drilling and completion							*80*	563		3836

B.4 Gjøa

CAPEX FACILITIES OVERVIEW										mill.NOK
Cost element	Engineering	Procurement	Construction	SUM EPC	Marine op	SUM EPCI	Management	Base estimate	Contingency	Total
Topsides	2049	3749	2172	7970	83	8053	1127	9180	1377	10557
Substructure incl conductors/risers	266	558	903	1727	230	1956	274	2230	335	2565
Piles, anchors and mooring lines	0	248	0	248	133	381	53	434	65	499
Sum Platform	*2315*	*4555*	*3075*	*9945*	*445*	*10390*	*1455*	*11845*	*1777*	*13621*
Subsea/WHP production equipment	197	1340	49	1586	123	1709	239	1948	292	2240
Flowlines and spools	45	342	186	573	332	905	127	1032	155	1186
Structures (RB, PLET, PLEM, T, Y)	69	191	0	260	145	405	57	462	69	531
Risers for flowlines/pipelines	81	449	53	583	62	645	90	735	110	846
Umbilicals with risers	45	156	22	222	67	289	40	329	49	379
Sum Subsea	*437*	*2477*	*309*	*3224*	*729*	*3953*	*553*	*4506*	*676*	*5182*
Export pipelines	42	802	162	1007	781	1788	250	2038	306	2344
Power cables wih risers	40	274	6	319	176	496	69	565	85	650
SUM Facilities	*2834*	*8108*	*3553*	*14495*	*2131*	*16626*	*2328*	*18954*	*2843*	*21797*
CAPEX WELLS OVERVIEW							**days per well**	**days**		**mill.NOK**
Drilling							*53*	587		2680
Completion							*47*	512		2518
Drilling and completion							*100*	1098		5198

C. Cost Verification Result of Each Development Project

Field	Year	Stortinget Data (mill NOK)	ACES (mill NOK)	Difference
Edvard Grieg	2012	25,810	26,073	1%
	2013	23,995	25,508	6%
	2014	27,157	27,686	2%
	2015	27,943	27,782	1%

Field	Year	Stortinget Data (mill NOK)	ACES (mill NOK)	Difference
Ivar Aasen	2012	24,300	23,841	2%
	2013	25,318	24,347	4%
	2014	25,630	24,906	3%
	2015	26,114	26,135	0%

Field	Year	Stortinget Data (mill NOK)	ACES (mill NOK)	Difference
Gjøa	2007	28,187	26,140	7%
	2008	29,766	27,543	7%
	2009	32,854	31,820	3%
	2010	34,622	32,895	5%
	2011	33,445	31,373	6%

Field	Year	Stortinget Data (mill NOK)	ACES (mill NOK)	Difference
*Aasta Hansteen	2013	41,953	45,825	9%
	2014	42,689	43,473	2%
	2015	43,880	46,795	7%

* include Polarled gas pipeline project

D. Cost Proportions of Each Development Project

D.1 Cost proportions for facilities development

Total Cost (Million NOK)

Field	Engineering					Procurement					Construction				
	Platform	SPS	Pipelines	Cables	Total	Platform	SPS	Pipelines	Cables	Total	Platform	SPS	Pipelines	Cables	Total
Edvard Grieg	3975	0	107	0	4082	5699	0	618	0	6317	5038	0	209	0	5247
Ivar Aasen	2249	276	25	14	2563	4563	1116	146	60	5884	2896	298	45	4	3243
Aasta Hansteen	4005	618	383	129	5135	7726	2878	5478	816	16899	4799	474	1100	41	6414
Gjoa	2581	539	88	52	3260	4821	2579	848	286	8534	3342	411	208	19	3979
Total	12810	1433	602	195	15041	22810	6573	7090	1163	37635	16074	1182	1562	64	18883

Note: Edvard Grieg Cables is taken out from calculation because the value is 0

Cost Proportion (%)

Field	Engineering					Procurement					Construction				
	Platform	SPS	Pipelines	Cables	Average	Platform	SPS	Pipelines	Cables	Average	Platform	SPS	Pipelines	Cables	Average
Edvard Grieg	21%	0%	4%	0%	9%	31%	0%	25%	0%	19%	27%	0%	8%	0%	12%
Ivar Aasen	18%	10%	6%	9%	11%	37%	41%	35%	39%	38%	23%	11%	11%	3%	12%
Aasta Hansteen	19%	11%	3%	8%	10%	38%	52%	39%	53%	45%	23%	9%	8%	3%	11%
Gjoa	20%	11%	4%	8%	11%	37%	51%	37%	46%	43%	25%	8%	9%	3%	11%
Average	20%	11%	4%	9%	11%	35%	48%	34%	46%	41%	25%	9%	9%	3%	11%

Note: Edvard Grieg Cables is taken out from calculation because the value is 0

Total Cost (Million NOK)

Field	Marine Operation					Project Mgt					Contingency				
	Platform	SPS	Pipelines	Cables	Total	Platform	SPS	Pipelines	Cables	Total	Platform	SPS	Pipelines	Cables	Total
Edvard Grieg	1398	0	1223	0	2622	2420	0	331	0	2751	2499	0	433	0	2931
Ivar Aasen	1047	700	145	57	1949	1616	359	54	20	2049	1668	371	56	21	2115
Aasta Hansteen	1341	842	5250	359	7792	2685	723	1835	202	5445	2772	746	1894	209	5621
Gjoa	711	830	827	189	2558	1721	655	296	82	2754	1777	676	306	85	2843
Total	4499	2372	7446	605	14921	8442	1737	2516	304	12999	8715	1793	2688	314	13510

Note: Edvard Grieg Cables is taken out from calculation because the value is 0

Cost Proportion (%)

Field	Marine Operation					Project Mgt					Contingency				
	Platform	SPS	Pipelines	Cables	Average	Platform	SPS	Pipelines	Cables	Average	Platform	SPS	Pipelines	Cables	Average
Edvard Grieg	8%	0%	49%	0%	19%	13%	0%	13%	0%	9%	13%	0%	17%	0%	10%
Ivar Aasen	8%	25%	35%	37%	26%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
Aasta Hansteen	7%	15%	37%	23%	21%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
Gjoa	5%	17%	36%	30%	22%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
Average	7%	19%	40%	30%	24%	13%	13%	13%	13%	13%	13%	10%	14%	13%	13%

Note: Edvard Grieg Cables is taken out from calculation because the value is 0

D.2 Cost proportions for drilling & well completion

Total Cost (Million NOK)

Field	Drilling	Completion	Average	Total
Edvard Grieg	2608	1714	2161	4322
Ivar Aasen	4967	2656	3811	7623
Aasta Hansteen	1762	1943	1852	3704
Gjoa	2680	2518	2599	5198
Total	12016	8830	10423	20846

Cost Proportion (%)

Field	Drilling	Completion	Average
Edvard Grieg	10%	7%	8%
Ivar Aasen	21%	11%	16%
Aasta Hansteen	4%	4%	4%
Gjoa	10%	9%	10%
Average	11%	8%	9%

E. Estimation Result of Norwegian Deliveries in Each Development Project

E.1 Norwegian deliveries in facilities development

E.1.1. Edvard Grieg project

Cost Elements	*Fabrication/Assembly/Onshore Completion*			*Enginering & Design*			*Procurement*			*Marine Operation & Offshore Completion*			*Project Management*			*Total Value of Norwegian Goods & Services*
	Contractor/Sub-contractor	*Construction Site*	*Value of Norwegian Goods/ Services*	*Contractor/Sub-contractor*	*Engineering Site*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Sourcing Location*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Operator's-based Location*	*Value of Norwegian Goods/ Services*	*Contractor /Sub-contractor*	*Project Office*	*Value of Norwegian Goods/ Services*	
Platform	Kvaerner	Norway	83%	Kvaerner	Stord	91%	Kvaerner	local & abroad	37%	Kvaerner	Stord	24%	Lundin	Norway	95.00%	70%
Topsides	Kvaerner	Stord	67%	Kvaerner	Stord	82%	Kvaerner	Stord	41%	Kvaerner	Stord	45%	Lundin	Stord	95.00%	47%
1. Main deck	Kvaerner	Stord	100%	Aker Solutions	Oslo,Mumbai	76%	Various	local & abroad	60%	Kvaerner	Stord	100%				61%
2. Living Quarter	Apply Leirvik	Stord	100%	Apply Leirvik	Stord	100%	Various	local & abroad	70%	Prosafe	UK	30%				69%
3. Helideck	N/A	Singapore	0%	N/A	Singapore	0%	N/A	Singapore	0%	Thialf	Holland	5%				0%
4. Utility module	Kvaerner	Stord	100%	Aker Solutions	Oslo,Mumbai	76%	Various	local & abroad	68%	N/A	N/A	N/A				64%
5. Process module	Aker Solutions	Egersund	100%	Aker Solutions	Oslo,Mumbai	76%	Various	local & abroad	50%	N/A	N/A	N/A				58%
6. Flare stack	N/A	Poland	0%	N/A	Poland	0%	N/A	Poland	0%	N/A	N/A	N/A				0%
Substructure incl conductors	Kvaerner	Verdal	100%	Kvaerner	Oslo	100%	Kvaerner	local & abroad	33%	Kvaerner	Verdal	3%	Lundin	Stord	95.00%	57%
1. Cluster	Harland & Wolff	Belfast	0%	Harland and Wolf	Belfast	0%	H&W	Belfast	0%	FoundOcean	UK	0%				0%
2. Legs and bracings	EEW	Germany	0%	Kvaerner/EEW	Germany	75%	EEW	Germany	0%	Saipem	Italy	5%				15%
3. Other sub-components (e.g. risers, j-tubes, etc)	Various suppliers	Norway	100%	Various suppliers	Norway	100%	Various	Norway	100%	N/A	N/A	N/A				79%
Export pipelines	Allseas/Welspun	Holland/India	0%	J.P. Kenny/Technip	Stavanger	100%	Welspun/Shaw	local & abroad	7%	Allseas/Technip	Holland/Norway	23%	Lundin	Norway	90.00%	29%
1. Edvard Grieg Oil Pipeline	Allseas/Welspun	Swiss/India	0%	J.P. Kenny	Stavanger	100%	Welspun/Shaw	local & abroad	7%	Allseas	Holland	15%	Allseas			17%
2. Utsira High Gas Pipeline	Allseas/Welspun	Holland/India	0%	J.P. Kenny	Stavanger	100%	Welspun/Shaw	local & abroad	7%	Allseas	Holland	15%				17%
3. Connection of UHGP & EGOP to existing pipeline	Allseas/Welspun	Holland/India	0%	Technip	Stavanger	100%	Welspun/Shaw	local & abroad	8%	Technip	Stavanger/ Haugesund	40%				39%
Power cables wih risers	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total			***46%***			***63%***			***22%***			***22%***			***93%***	***64%***

E.1.2. Aasta Hansteen Project (include Polarled gas pipeline)

Cost Elements	Fabrication/Assembly/Onshore Completion			Enginering & Design			Procurement			Marine Operation & Offshore Completion			Project Management			Total Value of Norwegian Goods & Services
	Contractor/Sub-contractor	Construction Site	Value of Norwegian Goods/ Services	Contractor/Sub-contractor	Engineering Site	Value of Norwegian Goods/ Services	Contractor/ Sub-contractor	Sourcing Location	Value of Norwegian Goods/ Services	Contractor/ Sub-contractor	Operator's-based Location	Value of Norwegian Goods/ Services	Contractor /Sub-contractor	Project Office	Value of Norwegian Goods/ Services	
Platform	Hyundai (HHI)	S. Korea	17%	Various	Various	8%	HHI	local & abroad	13%	Kvaerner	UK/Holland	52%	Statoil	Norway	93%	39%
Topsides	Hyundai (HHI)	S. Korea	0%	CB&I & Aker	Holland/SG	0%	HHI	local & abroad	10%	Kvaerner/Dockwise	Norway,Holland	46%	Statoil	Norway	93%	4%
1. Main Deck	Hyundai (HHI)	S. Korea	0%	CB&I	Holland/SG	0%	Various	local & abroad	15%	Kvaerner	Digernessundet	92%				6%
2. Living Quarter & Helideck	Hertel Offshore	Holland	0%	Hertel Offshore	Holland	0%	Various	local & abroad	3%	Dockwise	Netherland	0%				1%
3. Process module	Hyundai (HHI)	S. Korea	0%	CB&I	Holland/SG	0%	Various	local & abroad	20%							7%
4. Utility module	Hyundai (HHI)	S. Korea	0%	CB&I	Holland/SG	0%	Various	local & abroad	5%							2%
5. Flare stack	Hyundai (HHI)	S. Korea	0%	CB&I	Holland/SG	0%	Various	local & abroad	5%							2%
Substructure	Hyundai (HHI)	Ulsan, S. Korea	33%	Technip	Houson	17%	Hyundai (HHI)	local & abroad	17%	Kvaerner/Subsea 7	Norway	58%	Statoil	Norway	93%	17%
1. Hull	Hyundai (HHI)	Ulsan, S. Korea	0%	Technip	Houston	0%	Various	local & abroad	20%	Kvaerner	Digernessundet	93%				7%
2. Steel Catenary Risers	Subsea 7	Vigra, Norway	100%	Technip/Subsea 7	Houston	50%	Various	local & abroad	30%	Subsea 7	Helgeland	80%				45%
3. Mooring lines	Lankhorst Ropes	Portugal	0%	Technip	Houston	0%	Lankhorst Ropes	Portugal	0%	Dockwise	Netherland	0%				0%
Subsea System	Subsea 7/Aker	Norway	100%	Subsea 7/Aker/Technip	Various	92%	Subsea 7/Momek/Aker	local & abroad	48%	Subsea 7 & EMAS	Helgeland	82%	Statoil	Norway	100%	69%
1. Flowlines & piles	Subsea 7	Vigra, Norway	100%	Subsea 7	North Norway	100%	Various	local & abroad	40%	Subsea 7	Helgeland	80%				40%
2. Spools	Subsea 7/Aker	Sandnessjøen /Vigra	100%	Subsea 7	North Norway	100%	Various	local & abroad	50%	Subsea 7	Helgeland	80%				45%
3. FPSO Suction anchors	Subsea 7/Momek	Mo i Rana	100%	Technip/Subsea 7	Houston/Norway	80%	Various	local & abroad	70%	Subsea 7	Helgeland	80%				53%
4. Riser Base & PLETS	Subsea 7/Momek	Mo i Rana	100%	Subsea 7	North Norway	100%	Various	local & abroad	70%	Subsea 7	Helgeland	80%				56%
5. Umbilicals & umbilical bas	Aker Solutions	Moss/Egersund	100%	Aker Solutions	Fornebu, UK, MY	88%	Various	local & abroad	25%	Subsea 7	Helgeland	80%				31%
6. Templates	Aker Solutions	Sandnessjøen /Egersund	100%	Aker Solutions	Fornebu, UK, MY	88%	Various	local & abroad	50%	EMAS AMC	Sandness jøen	95%				44%
7. Manifolds	Aker Solutions	Sandnessjøen /Egersund	100%	Aker Solutions	Fornebu, UK, MY	88%	Various	local & abroad	50%	Subsea 7	Helgeland	80%				44%
8. Subsea Xmas Trees and Wellheads	Aker Solutions	Tranby	100%	Aker Solutions	Fornebu, UK, MY	88%	Various	local & abroad	30%	Subsea 7	Helgeland	80%				34%
Export pipelines	JFE/Itochu/Wasco /NEMO	Japan/MY/ Norway	50%	Rambøll/Reinertsen/NEMO	Denmark/ Norway	16%	JFE/Itochu/ Wasco/NEMO	Japan/MY/Norway	46%	Allseas/DOF Subsea/Deep Ocean	Norway/UK/ Holland	73%	Statoil	Norway	90%	63%
1. Pipes	JFE/Itochu	Japan	0%	Rambøll/ Reinertsen	Denmark/ Trondheim	50%	JFE/Itochu	Japan	0%	Grieg Shipping	Bergen	80%				1%
	Wasco	Malaysia	0%	Rambøll/ Reinertsen	Denmark/ Trondheim	50%	Wasco	Malaysia	0%	Allseas	Netherland	32%				1%
	Wasco	Mo i Rana	100%	Rambøll/ Reinertsen	Denmark/ Trondheim	50%	Wasco	Mo i Rana	100%	DOF Subsea	Norway	100%				48%
2. Subsea Installation and ot	NEMO	Drammen	100%	Kongsberg (NEMO	Asker	100%	NEMO	local & abroad	85%	Deep Ocean	UK-based	80%				44%
Fiber optic cables	Deep Ocean	UK	0%	Deep Ocean	UK	0%	Deep Ocean	Germany	0%	Deep Ocean	UK	0%	Statoil	Norway	95%	12%
Control Cables	Aker Solution	Moss	100%	Aker Solution	Fornebu	100%	Aker Solutions	Aberdeen	0%	Subsea 7	Helgeland	85%	Statoil	Norway	100%	46%
Safety and Control System	ABB Norway	Sweden	0%	ABB Norway	Norway	100%	ABB Norway	Overseas	0%	N/A	N/A	N/A	Statoil	Norway	90%	20%
Total			*19%*			*38%*			*20%*			*78%*			*95%*	*44%*

E.1.3. Gjøa Project

Cost Elements	*Fabrication/Assembly/Onshore Completion*			*Enginering & Design*			*Procurement*			*Marine Operation & Offshore Completion*			*Project Management*			*Value of Norwegian Goods & Services*
	Contractor/ Sub-contractor	*Construction Site*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Engineering Site*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Sourcing Location*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Operator's-based Location*	*Value of Norwegian Goods/ Services*	*Company*	*Project Office*	*Value of Norwegian Goods/ Services*	
Platform	Aker/Samsung	Stord/S. Korea	75%	Aker Solutions	Oslo/Stord/Mumbai	68%	Aker/Samsung	local & abroad	48%	Aker Marine	Stord	81%	Statoil/GdF	Norway	95%	73%
Topsides	Aker Solutions	Stord	100%	DNV/Aker	Oslo & Mumbai	71%	Various	local & abroad	71%	Aker Marine	Stord	100%	Statoil/GdF	Norway	100%	65%
1. Main Deck	Aker Solutions	Stord	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	60%	Aker Marine	Stord	100%				59%
2. Living Quarter & Helideck	Appy Leirvik	Stord	100%	Appy Leirvik	Stord	100%	Various	local & abroad	70%	Island Offshore	Norway	100%				70%
3. Process module	Aker Solutions	Egersund	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	60%							59%
4. Utility module	Aker Solutions	Stord	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	70%							63%
5. Risers module	Aker Solutions	Egersund	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	70%							63%
6. Flare tower	Kvaerner	Verdal	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	70%							63%
7. Gas Turbine	N/A	N/A	N/A	N/A	N/A	N/A	Dresser-Rand	Norway	100%							37%
Substructure incl conductors	Samsung	S.Korea	50%	Aker Solutions	Oslo & Mumbai	65%	Samsung	local & abroad	24%	Aker/Technip/etc	Norway	62%	Statoil/GdF	Norway	90%	34%
1. Hull	Samsung	S.Korea	0%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	10%	Dockwise	Holland	0%				16%
2. Gas export smoothbore ris	Technip	Le Trait, France	0%	Technip	Oslo	100%	Various	local & abroad	0%	Technip	Sandvika	40%				20%
3. Flexible risers	NKT	Denmark	0%	Aker Solutions	Oslo & Mumbai	65%	NKT	Overseas	0%	Acergy	Stavanger	80%				13%
4. Moorings lines	Aker Solutions	Pusnes	100%	Aker Solutions	Oslo & Mumbai	65%	Various	local & abroad	86%	Aker Marine	Stord	90%				69%
Deep penetrating anchors	N/A	Lithuania	N/A	Deep Sea	Trondheim	N/A	N/A	N/A	N/A	Deep Sea	Norway	100%				100%
Subsea System	FMC/Subsea 7/Technip	Norway & Overseas	88%	FMC/Subsea 7/Technip	Norway & Overseas	93%	FMC/Subsea 7/Technip	local & abroad	40%	Subsea 7/Acergy/Techni	Stavanger, Sandvika	63%	Statoil	Norway	90%	60%
1. Flowlines Gjøa field	Technip	Orkanger	100%	Technip	Oslo	100%	Various	Norway, Japan	40%	Technip	Sandvika	40%				40%
2. Spools Gjøa Field	Technip	Orkanger	100%	Technip	Oslo	100%	Various	local & abroad	40%	Technip	Sandvika	40%				40%
3. Umbilicals Gjøa Field	Aker Subsea	Moss, Norway	100%	Aker Subsea	Oslo	100%	Aker Subsea	Norway	23%	Acergy	Stavanger	70%				31%
4. Templates Gjøa Field	FMC Tech	Kongsberg	100%	FMC Tech	Kongsberg	100%	Various	local & abroad	50%	Acergy	Stavanger	70%				45%
5. Manifolds Gjøa Field	FMC Tech	Kongsberg	100%	FMC Tech	Kongsberg	100%	Various	local & abroad	50%	Subsea 7	Stavanger	70%				45%
6. Subsea Xmas Trees and W	FMC Tech	Dunfermline	0%	FMC Tech	Kongsberg	100%	Various	local & abroad	13%	Subsea 7	Stavanger	70%				18%
7. PLETs Gjøa Field	Subsea 7	Vigra, Norway	100%	Subsea 7	London/Stavanger	70%	Kongsberg AS	Asker	60%	Subsea 7	Stavanger	70%				47%
12. MEG lines	Subsea 7	Vigra, Norway	100%	Subsea 7	London/Stavanger	70%	Various	local & abroad	40%	Subsea 7	Stavanger	70%				37%
Export pipelines	Mitsui/Metal One/Shaw	Japan/ Scotland	0%	Rambøll & N/A	Denmark/Norway	50%	Mitsui/Metal One/Shaw	Japan/ Scotland	0%	Saipem	London	28%	Statoil	Norway	100%	25%
1. Oil export pipeline	Mitsui/Shaw	JP/Scotland	0%	Rambøll & N/A	Denmark/Norway	50%	Mitsui/Shaw	JP/Scotland	0%	Saipem	London	27%				1%
2. Gas export pipeline	Metal 1/Shaw	JP/Scotland	0%	Rambøll & N/A	Denmark/Norway	50%	Metal 1/Shaw	JP/Scotland	0%	Saipem	London	27%				1%
3. Rock dumping	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dutch Firm	Holland	30%				30%
Power cable (From shore)	ABB AB	Sweden	0%	ABB AB	Sweden	0%	ABB AB	Sweden	0%	Ocean Team	Norway	90%	Statoil	Norway	100%	36%
Total			*38%*			*46%*			*24%*			*55%*			*96%*	*48%*

E.1.4. Ivar Aasen Project (include Hanz)

Cost Elements	*Fabrication/Assembly/Onshore Completion*			*Enginering & Design*			*Procurement*			*Marine Operation & Offshore Completion*			*Project Management*			*Value of Norwegian Goods & Services*
	Contractor/ Sub-contractor	*Construction Site*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Engineering Site*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Sourcing Location*	*Value of Norwegian Goods/ Services*	*Contractor/ Sub-contractor*	*Operator's-based Location*	*Value of Norwegian Goods/ Services*	*Company*	*Project Office*	*Value of Norwegian Goods/ Services*	
Platform	SMOE/Saipem	SG/Italy	8%	Wood/Saipem	Norway/London/KL	8%	SMOE/Saipem	local & abroad	19%	Aibel/Saipem	Norway/Italy	29%	Det Norske	Norway	90%	26%
Topsides	SMOE Ltd	Singapore	17%	Wood/Apply	London/KL/Norway	17%	SMOE Ltd	local & abroad	29%	Aibel/Saipem	Norway/Italy	47%	Det Norske	Norway	90%	17%
1. Main Deck	SMOE Ltd	Singapore	0%	Wood Group	London/KL	0%	Various	local & abroad	10%	Aibel	Stavanger	100%				3%
2. Living Quarter	Apply Leirvik	Stord	100%	Apply Leirvik	Stord	100%	Various	local & abroad	70%	Saipem	Italy	10%				69%
3. Helideck	N/A	China	0%	N/A	China	0%	N/A	China	0%	Eide Marine	Norway	100%				0%
4. Process module	SMOE Ltd	Singapore	0%	Wood Group	London/KL	0%	Various	local & abroad	50%	Dockwise	Netherland	0%				17%
5. Utility module	SMOE Ltd	Singapore	0%	Wood Group	London/KL	0%	Various	local & abroad	50%							17%
6. Flare stack	SMOE Ltd	Singapore	0%	Wood Group	London/KL	0%	Various	Overseas	0%							0%
7. Flotel for commisioning	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Prosafe	United Kingdom	25%	N/A	N/A	N/A	0%
8. Wellheads & Xmas Trees	N/A	N/A	N/A	N/A	N/A	N/A	FMC Tech	local & abroad	20%							7%
Substructure incl conductors	Saipem	Italy	0%	Saipem	London	0%	Saipem	local & abroad	10%	Saipem/Heerema	Italy/Holland	10%	Det Norske	Norway	90%	3%
1. Hull	Saipem	Italy	0%	Saipem	London	0%	Various	local & abroad	10%	Saipem	Italy	10%				0%
										Heerema (Thialf)	Netherland	1%				10%
Subsea System	Subsea 7/EMAS/FMC	Norway, UK	83%	Subsea 7/EMAS/FMC	Norway	100%	Subsea 7/EMAS/FMC	local & abroad	20%	Subsea 7/EMAS	Norway	50%	Det Norske	Norway	100%	53%
1. Flowlines & Flowlines pile	Subsea 7	Vigra	100%	Subsea 7	Stavanger	100%	Various	local & abroad	40%	Subsea 7	Stavanger	55%				37%
2. Spools	EMAS AMC	Gulen	100%	EMAS AMC	Oslo	100%	EMAS AMC	USA	0%	EMAS AMC	Oslo	40%				21%
3. PLETS	EMAS AMC	Gulen	100%	EMAS AMC	Oslo	100%	EMAS AMC	USA	0%	EMAS AMC	Oslo	40%				21%
4. Umbilicals & umbilical rise	Subsea 7/Aker	Moss	100%	Subsea 7	Stavanger	100%	Aker Kvaerner	Norway	20%	Subsea 7	Stavanger	55%				29%
5. Templates-Manifolds	FMC Tech	Kongsberg	100%	FMC Tech	Kongsberg	100%	Various	local & abroad	40%	Subsea 7	Stavanger	55%				37%
6. Subsea Xmas Tree and We	FMC Tech	Dunfermline	0%	FMC Tech	Kongsberg	100%	Various	local & abroad	20%	Subsea 7	Stavanger	55%				18%
Subsea pipelines	EMAS AMC	Gulen	100%	EMAS AMC	Oslo	100%	Various	local & abroad	12%	EMAS AMC	Oslo	40%	Det Norske	Oslo	100%	49%
Power cables (connected to I	ABB AB	Sweden	0%	ABB AB	Sweden	0%	ABB AB	Sweden	0%	EMAS AMC	Oslo	40%	Det Norske	Norway	100%	28%
EICT Package	Siemens	Norway/ Germany	70%	Siemens/Eldor	Norway/Mumbai/ London	33%	Siemens	Norway/ Germany	40%	N/A	N/A	N/A	Siemens/ Det Norske	Norway	100%	51%
Total (with subsea system for Hanz)			***33%***			***25%***			***19%***			***51%***			***98%***	***44%***

E.2 Norwegian deliveries in drilling & well completion (1)

Field	Engineering Drilling & Completion			Jack-up/Semi-sub Drilling + Completion			Consumables (mud, chemicals, etc)			Casing (conductors/casing/tubing)			Other Equipment			
	Contractor (s)	Enginnering Office	Value of Norwegian Goods/ Services	Contractor (s)	Drilling Rig's Registered Location	Value of Norwegian Goods/ Services	Contractor (s)	Sourcing Location	Value of Norwegian Goods/ Services	Contractor (s)	Sourcing Location	Value of Norwegian Goods/ Services	Good(s)	Contractor (s)	Sourcing Location	Value of Norwegian Goods/ Services
Edvard Grieg	Lundin	Norway	7%	Rowan	Marshall	16%	Statoil Fuel & Retail	Norway	31%	N/A	Overseas	1%	Seal Connections	Tenaris	Luxembourg	0%
					Island		M-I-Swaco Norge	Norway	9%				Wellheads & Xmas Trees	Aker Solutions	Norway	9%
													Valve system	Score Group Plc	Norway	14%
													Valve system	Ellingsen	Norway	14%
													Crane & lifts	NOV	Norway	9%
													Pumps & generators	Eureka Pumps AS	Norway	14%
Total			7%			16%			20%			1%				10%
Norwegian Deliveries			100%			40%			65%			3%				33%
Ivar Aasen	Det Norske	Norway	7%	Maersk	Singapore	16%	Statoil Fuel & Retail	Norway	33%	N/A	Overseas	1%	Wellheads & Xmas Trees	FMC Technologies	UK & France	5%
							M-I-Swaco Norge AS	Norway	10%				Surface wellhead & mudline equipment	Plexus Holding Plc	UK	0%
													Valve system	Score Group Plc	Norway	15%
													Crane & lifts	N/A	Norway	10%
													Pumps & generators	N/A	Norway	15%
Total			7%			16%			21%			1%				9%
Norwegian Deliveries			100%			38%			65%			3%				27%
Gjoa	Statoil/GdF	Norway	7%	Transocean	Marshall	17%	Statoil Fuel & Retail	Norway	22%	N/A	Overseas	1%	Gyrolok tube fittings, tubing, valves, heat trace tubing, instrument enclosures	Teamtrade	Norway	6%
					Island		M-I-Swaco Norge AS	Norway	6%				Valve system	ATV	Milan	0%
													Crane & lifts	N/A	Norway	6%
													Pumps & generators	PG Pumps Solution	Norway	6%
													Seal connections	Tenaris	Overseas	0%
Total			7%			17%			14%			1%				4%
Norwegian Deliveries			100%			35%			65%			3%				18%
Aasta Hansteen	Statoil	Norway	7%	N/A	Overseas	28%	Statoil Fuel & Retail	Norway	19%	N/A	Overseas	1%	Valve system	N/A	Norway	8%
							M-I-Swaco Norge AS	Norway	6%				Crane & lifts	N/A	Norway	6%
													Pumps & generators	N/A	Norway	9%
													Seal connections	Tenaris	Overseas	0%
													Wellheads & Xmas Trees	Aker Solutions	Norway	7%
Total			7%			28%			12%			1%				6%
Norwegian Deliveries			100%			54%			65%			3%				32%

E.3 Norwegian deliveries in drilling & well completion (2)

Field	Other Works				Logistic (supply, helicopters, catering)				Well Services				Total Norwegian Deliveries
	Service(s)	Contractor (s)	Sourcing Location	Value of Norwegian Goods/ Services	Service(s)	Contractor (s)	Sourcing Location	Value of Norwegian Goods/ Services	Service(s)	Contractor (s)	Contractor's Registered Location	Value of Norwegian Goods/ Services	
Edvard Grieg	Maintenance Crew	N/A	Norway	31%	Helicopter services	Bristow Norwa	Norway	31%	Wireline service	DeepWell	Norway	17%	
	Supply vessel	Island Offshore	Norway	25%	Catering services	ESS Support Se	Norway	31%	"Well Tractor"	Welltec	Denmark	0%	
	Supply vessel	Eidesvik AS	Norway	25%	Supply base	ASCO Norge AS	Norway	31%	Completion Equ	N/A	Norway	4%	
	Maintenace Equipment	N/A	Norway	6%					Instrument & Co	Roxar AS	Norway	18%	
									Completion cre	N/A	Norway	19%	
Total				21%				31%				12%	15%
Norwegian Deliveries				70%				100%				55%	58%
Ivar Aasen	Supply vessel	N/A	Norway	26%	Helicopter services	Bristow Norwa	Norway	33%	Completion cre	Schlumberge	Norway	19%	
	Maintenance Crew	Schlumberger AS	Norway	33%	Catering services	N/A	Norway	33%	Completion equ	Schlumberge	Norway	4%	
	Maintenance Equipment	Schlumberger AS	Norway	4%	Supply base	ASCO Norge AS	Norway	33%					
Total				21%				33%				12%	15%
Norwegian Deliveries				64%				100%				62%	57%
Gjoa	Supply vessel	O.H. Meling & Co.	Norway	17%	Helicopter services	CHC Helicopte	Norway	22%	Completion cre	Schlumberge	Norway	22%	
	Maintenance Crew	Schlumberger No	Norway	22%	Catering services	N/A	Norway	22%	Completion equ	Schlumberge	Norway	2%	
	Maintenance Equipment	Schlumberger No	Norway	2%	Supply base	Fjord Base AS	Norway	22%					
Total				14%				22%				12%	11%
Norwegian Deliveries				63%				100%				55%	55%
Aasta Hansteen	Supply vessel	N/A	Norway	15%	Helicopter services	CHC Helicopter Services AS		19%	Completion cre	N/A	Norway	22%	
	Maintenance Crew	N/A	Norway	19%	Catering services	N/A		19%	Completion equipment		Norway	7%	
	Maintenance Equipment	N/A	Norway	4%	Supply base	Asco Norge AS		19%					
Total				13%				19%				14%	12%
Norwegian Deliveries				68%				100.0%				65%	61%