NTNU – Trondheim
Norwegian University of
Science and Technology

Case Study - Business Mapping to Improve Quality of the Well Delivery Process

Jens Erich Jenssen

Petroleum Engineering
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Supervisor: Sigbjørn Sangesland, IPT

Norwegian University of Science and Technology
Department of Petroleum Engineering and Applied Geophysics

NTNU
Norges teknisk-naturvitenskapelige universitet
Studieprogram i Geofag og petroleumsteknologi
Study Programme in Earth Sciences and Petroleum Engineering

Fakultet for ingeniørvitenskap og teknologi
Faculty of Engineering and Technology

Institutt for petroleumsteknologi og anvendt geofysikk
Department of Petroleum Engineering and Applied Geophysics

HOVEDOPPGAVE/DIPLOMA THESIS/MASTER OF SCIENCE THESIS

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Background:
The exploration and production (E&P) industry is facing an uncertain future, which will impact the availability and cost of fuels. An important task for the future will be, amongst other things, to increase the recovery factor on the Norwegian Continental Shelf (NCS). Business maps and benchmark studies have the potential of increasing the efficiency and improve critical processes and operations in an E&P company. Established E&P organisations as well as E&P organisations preparing for operations may benefit from developing operational blueprints (best practice) and business models, as they have the potential of detecting areas of improvement and ameliorate operations.

Task:

1) Compare the well delivery process in a region (from request to drill, to close out and hand over to production) to a base case on the NCS. Describe common relations and challenges in the two regions.
2) Discuss challenges for the well delivery process, which are not relevant for the base case.
3) By using business mapping and benchmarking, propose a strategy for how to improve the well delivery process. Discuss what can, and what cannot, be transferred from the base case with focus on optimizing the well delivery process, i.e., how to best capitalize/exploit lessons learned (people), processes and technology from the NCS.
4) In light of process proposed above, compare the differences in opportunities and challenges (people, process and technology) facing the regions as they prepare for their future challenges.

Supervisor	*Sigbjørn Sangesland*
Co-supervisor	*Ole Evensen (PwC Stavanger)*
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Preface

This master's thesis has been written as the final part of a Master of Science degree in Petroleum Technology at the Norwegian University of Science and Technology (NTNU). The research has been conducted during the spring semester of 2012. During the master's degree the author has specialized in drilling technology, with extra courses in finance and economics. Prior to the thesis, the author performed a literature review of methods for cost saving in field development and well planning.

I want to take this opportunity thank several individuals for guidance and support during this challenging yet interesting semester.

I would like to thank my study supervisor Professor Sigbjørn Sangesland for guidance throughout the writing of my thesis. I would also like to thank Professor II Johan Eck-Olsen for important input and establishing contact with personnel employed at the operating company on the Norwegian Continental Shelf. Thanks to Hogne Kile for very useful discussions and guidance during the study. Finally, a great thank you to Partner Ole Evensen, Director Eirik Rassmusen and Senior Associate Thomas Gabrielsen at PriceWaterhouseCoopers Stavanger for providing me with a highly relevant business case and important information. Their cooperation and support has been mostly appreciated.

Executive Summary

The importance of building a robust oil and gas company is currently more relevant than ever. Volatile oil prices, challenging governmental relations and uncertain outcomes of exploration activities are all elements affecting operating companies in the global oil and gas industry. Another important element is the cost of upstream services, which has increased dramatically since the beginning of the new millennium. There IS no reason to believe that future challenges will be any easier to overcome. Simultaneously, the global community is in need of more energy to meet the predicted increase in demand.

It is therefore important for operating companies to focus on increased recovery and secure safe and effective operations. By emphasizing quality in the well delivery process (WDP) operating companies can reduce time spent on planning wells, accelerate project development and increase focus on safety. A high quality WDP can secure proper technology assessment, process ownership, staff accountability, improve allocation of key resources and secure continuos improvement. With a properly functioning WDP future well projects can be delivered in an improved manner, thus helping operating companies build a robust organization able to meet an uncertain future.

This study has analyzed the WDP of an operating company located in the Middle East with emphasis on revealing existing challenges. The findings have been compared to a base case WDP of an operating company located on the Norwegian Continental Shelf (NCS). Based on analysis and lessons learned from the NCS improvements have been suggested.

The WDP defines the set of activities in place to plan, execute and deliver a well. The process is important as it secure the presence of several critical elements during well planning and drilling operations. It must be able to secure participation of experienced employees, cooperation between important departments, use of technical solutions and documentation of lessons learned. The difference between a well functioning and poorly functioning WDP can be severe. A poor process will reduce HSE focus, fail to secure use of new drilling technology, increase costs and lead to an inefficient allocation of resources.

Several challenges reducing the quality of the WDP of the OME were revealed during the analysis. A high number of change orders combined with a lack of processes to deal with change reduce the quality of the WDP significantly. Other important challenges discovered include lacking interdisciplinary communication, insufficient focus on continuos improvement and absence of process ownership among employees in the drilling and well department. In addition, a lack of formal decision points to support the WDP was revealed.

The study also found similar challenges between the WDP's of the two companies. It was revealed that both operating companies use deviating targets and performance indicators that compromise cooperation. Companies also experience difficulties in communicating lessons learned, challenges with an insufficient supply of drilling rigs and a scarcity of qualified personnel. This reduce quality of the WDP and increase risk.

A greater number of challenges in the WDP were discovered for the operating company in the Middle East. As oppose to the operating company on the NCS, the operator in

the Middle East has little or no focus on implementing lessons learned and lack process ownership among employees. The OME also lack a dynamic planning regime and has an insufficient focus on HSE.

Several opportunities for improving the WDP of the operator in the Middle East were discovered during the study. Suggested improvements include establishment of cooperation forums to enhance flow of information and increase collaboration between the field development and drilling and well department. It is also suggested to implement rigid processes and revise the use of targets and performance indicators. KPI's that favor cooperation across departments should also be established.

Based on lessons learned from the NCS it is suggested to implement decision gates to support existing processes. It is also recommended to establish post activities and implement dedicated change management process steps. This will support lessons learned and increase the focus on managing risk and uncertainty in the WDP.

The suggested improvements will increase the quality of the WDP. They will help secure process ownership and staff accountability, reduce time spent on planning the well and accelerate project development, increase safety aspects, improve allocation of key resources and secure continuos improvement.

The study also analyzed future opportunities and challenges in the two regions using a PESTEL-analysis. Future opportunities in the Middle East include elevated political influence as an increasing part of remaining global oil and gas resources will be located in the region. Future challenges include an increase in resource complexity, volatility in the political environment and difficulties in attracting the necessary expertise and technology.

Common opportunities for the two regions include future predictions of high oil prices, technological progress making previous unavailable resources available, improved carbon capture and storage (CCS) methods to mitigate the environmental impact of the industry and opportunities as a result of an increased focus of the importance of providing energy to the global community. Common challenges include the chance of oil and gas becoming redundant and a strong dependency on prices of hydrocarbons. This makes regions vulnerable for a decline in oil and gas prices.

Suggested future work includes analysis of the WDP in an increased number of operating companies to confirm or invalidate the presented findings. It would also be interesting to investigate the use of incentives and performance indicators and analyze their effect the WDP. Studies investigating methods to improve efficiency in drilling and well operations are also interesting. It is also suggested to compare average recovery rates in oil and gas regions and investigate reasons for any existing differences.

Sammendrag

Viktigheten av å bygge et robust olje- og gasselskap er i dag mer framtredende enn noen sinne. Fluktuerende oljepriser, oljelekasjer, utfordrende politiske relasjoner, usikre utfall av leteaktiviteter og strenge miljøhensyn er kun noen av elementene som operatørselskap i olje- og gassindustrien må håndtere. Et annet viktig element er hvordan kostnader forbundet med oppstrømsaktiviteter har økt kraftig siden år 2000. Det er ingen grunn til å forvente at framtidige utfordringer for operatøselskap i industrien vil bli mindre krevende. I tillegg øker den globale etterspørselen etter energi.

På bakgrunn av dette er det viktig at operatørselskap fokuserer på økt utvinning og tilstreber sikre og effektive operasjoner. Ved å fokusere på kvalitet i brønnleveranseprosessen kan operatørselskap redusere brønnplanleggingstid, akselerere prosjektutvikling og øke sikkerhetsfokus. En brønnleveranseprosess av høy kvalitet vil sikre dette og i tillegg legge til rette for utnyttelse av ny teknologi, implementere ansattes eierskap til viktige delprosesser, forbedre ressursallokeringen i selskapet og legge til rette for kontinuerlig forbedring. Med en velfungerende brønnleveranseprosess vil framtidige prosjekter bli levert på en bedre måte. Dette kan øke rubustheten til operatørselskap og gjøre de bedre forbredt på å møte framtidige utfordringer.

Dette studiet har analysert brønnleveranseprosessen til et operatørselskap lokalisert i Midtøsten med fokus på å avdekke utfordringer. Funnene i analysen har blitt sammenliknet med en liknende prosess til et operatørselskap på norsk sokkel. Deretter har forbedringstiltak i brønnleveranseprosessen til operatøren i Midtøsten blitt foreslått. Erfaringer fra norsk sokkel har også blitt brukt.

Det ble avdekket flere utfordringer som reduserer kvaliteten i brønnleveranseprosessen til operatørselskapet i Midtøsten. Blandt de viktigste funnene nevnes manglende kommunikasjon mellom hovedavdelinger og manglende prosesser som adresserer ringvirkninger av kritiske forandringer. Utfordringer som et resultat av et høyt antall forandringer i brønndesignet og manglende prosesser for å inkorporere forandringer ble også oppdaget. I tillegg ble et manglende fokus på å dokumentere erfaringer og fraværende tilrettelegging for kontinuerlig forbedring avdekket.

Analysene viste også flere like utfordringer som reduserer kvaliteten på brønnleveranseprosessen til de operatørselskapene. Disse inkluderer viktigheten av åsikre erfaringsoverføring og nødvendigheten av ågjennomgå eksisterende mål og indikatorer som reduserer samarbeid mellom avdelinger. Felles utfordringer ved å få tak i tilstrekkelig antall borerigger og en knapphet på kvalifisert arbeidskraft ble også avdekket.

Totalt sett ble et større antall utfordringer oppdaget hos operatøren i Midtøsten. I motsetning til operatøren på norsk sokkel ble det her avdekket et manglende fokus på å sikre og inkorporere forbedringer basert på tidligere læring. Det ble også oppdaget en manglende etterlevelse av prosesser og utilstrekkelig fokus på HMS i planleggingsfasen.

Det er grunn til å tro at offshoreoperasjoner og høye løftekostnader har gitt operatørselskapet på norsk sokkel større grunn til å fokusere på effektivitet i prosesser og under operasjoner. Dette kan forklare noen av forskjellene i utfordringene mellom brønnleveranseprosessen hos operatørselskapet i Midtøsten og på norsk sokkel.

Det ble oppdaget flere muligheter for å forbedre brønnleveranseprosessen til operatøren i Midtøsten. Det kan etableres et samarbeidsforum mellom feltutviklingsavdelingen og boring- og brønnavdelingen, implementering av obligatoriske prosesser som krever etterfølgelse, en gjennomgang av eksisterende mål og prestasjonsindikatorer, i tillegg til etableringer av prestasjonsindikatorer som favoriserer samarbeid og kommunikasjon mellom avdelinger som avhenger av hverandre.

Basert på positive erfaringer fra operatørselskapet på norsk sokkel foreslås implementering av beslutningsporter for å støtte eksisterende prosesser, opprettelse av etteraktiviteter som støtter opp om erfaringsoverføring og kontinuerlig forbedring. Det foreslås også å øke fokus på risikohåndtering i forbindelse med endringer ved å implementere dedikerte forandringsprosesser i løpet av brønnleveranseprosessen.

Forbedringstiltakene vil øke effektiviteten og kvaliteten i brønnleveranseprosessen. Forslagene vil bidra til å sikre eierskap til prosesser og øke ansvarliggjøringen blandt ansatte. De vil redusere planleggingstiden, akselerere prosjektutviklingen, øke sikkerhetsfokuset og forbedre nåværende ressursallokering.

Studiet har også analysert framtidige muligheter og utfordringer i de to regionene ved hjelp av en PESTEL-analyse. Mulighetene i Midtøsten inkluderer blandt annet økt politisk innflytelse da en større og større andel av gjenværende globale olje- og gassressurser vil være lokalisert i regionen. Framtidige utfordringer inkluderer økt vanskelighetsgrad i utvinningen av gjenværende ressurser, politisk ustabilitet og utfordringer ved å tiltrekke seg nødvendig kompetanse og teknologi.

Felles muligheter i de to regionene inkluderer predikasjoner om en høy framtidig oljepris. Teknologiske framskritt vil kunne muligjøre utvinning av tidligere utilgjengelige ressurser, forbedrede metoder for lagring av CO_2 og redusere utslipp av klimagasser. Muligheter i form av økt fokus på viktigheten av å forsyne verdenssamfunnet med energi nevnes også. Felles utfordringer inkluderer muligheten for at teknologiframskritt gjør hydrokarboner overflødig og at den sterke avhengighen av få råvarer gjør regionene sårbare for sterkt reduserte olje- og gasspriser.

Av framtidig arbeid foreslås å gjøre analyser av brønnleveranseprosesser hos flere operatørselskap. Dette vil kunne verifisere eller falsifisere funnene gjort i dette studiet.

Det vil også være interessant å undersøke bruken av insentiver og prestasjonsindikatorer i brønnleveranseprosessen og undersøke deres effekt. Studier som tar for seg forskjellige metoder for å øke effektiviteten i bore- og brønnoperasjoner er også av stor interesse. I tillegg foreslås det å studere utvinningsgraden i forskjellige olje- og gassregioner og forsøke å begrunne forskjellene.

Contents

List of Figures

List of Tables

Nomenclature

AAR After Action Review.

BHA Bottom Hole Assembly.

BOD Basis of Design.

BOE Barrels of Oil Equivalent.

CCS Carbon Capture and Storage.

CWOP Complete Well On Paper.

DG Decision Gate - equivalent to Stage Gates.

DWOP Drill Well On Paper.

e.g. exempli gratia (latin) - for example.

E&P Exploration and Production.

EDI Equitable Depletion Index.

EIA Energy Information Administration.

EOR Enhanced Oil Recovery.

ERD Extended Reach Drilling.

FDP Field Development Plan.

FPS Floating Production System.

GDP Gross Domestic Product.

GoM Gulf of Mexico.

GOR Gas Oil Ratio.

HSE Health, Safety and Environment.

i.e. id est (latin) - that is.

ICD Inflow Control Devices.

IEA The International Energy Agency.

IMF International Money Fund.

IOR Increased Oil Recovery.

KPI Key Performance Indicator.

kWh Kilowatt hour.

McfE Thousand Cubic Feet of Natural Gas Equivalent.

MEL Master Equipment List.

MTBF Mean Time Between Failure.

Mtoe Million tonnes of oil equivalent.

NCS Norwegian Continental Shelf.

NPV Net Present Value.

OECD Organization for Economic Cooperation and Development.

OME Operator in the the Middle East.

ONCS Operator on the Norwegian Continental Shelf.

ONS Offshore Northern Seas

OPEC Organization of the Petroleum Exporting Countries.

OpEx Operational Expenditures.

POOH Pulling Out of Hole.

PwC PriceWaterhouseCoopers.

R&D Research and Development.

RACI Responsible Accountable Consulted Informed.

ROI Return On Investment.

RRR Reserve Replacement Ratio.

SDFI State's Direct Financial Interest

TLP Tension Leg Platform.

toe tonnes of oil equivalent.

UCCI Upstream Capital Cost Index.

UOCI Upstream Operating Cost Index.

VDS Value Delivery System.

WDP Well Delivery Process.

XMT X-mas tree - Christmas tree

1 Introduction

Purpose of Study

Volatile oil prices, possibilities of oil spills, challenging governmental relations, uncertain outcomes of exploration activities and environmental concerns are elements affecting operating companies in the oil and gas industry. Another important element is the cost of upstream services, which has increased dramatically since the beginning of the new millennium. There are no reasons to believe that future challenges will be any easier for companies within the industry to overcome. Simultaneously, the global community is in need of more energy to meet the predicted increase in demand.

Despite these challenges, operating companies in the oil and gas industry has experienced significant revenues throughout history. Contrarily, companies in other businesses has been reliant on developing effective processes to generate a positive income. The hypothesis is that a continuos presence of significant profits in the oil and gas industry has resulted in a lack of incentives to develop lean organizations and effective processes.

It is therefore important for operating companies to focus on increased recovery and secure safe and effective operations. By emphasizing quality in the well delivery process (WDP) operating companies can reduce time spent on planning wells, accelerate project development and increase focus on safety. A high quality WDP can secure proper technology assessment, process ownership, staff accountability, improve allocation of key resources and secure continuos improvement. With a properly functioning well delivery process future projects can be delivered in an improved manner, thus helping operating companies build a robust organization able to meet an uncertain future.

Established exploration and production (E&P) organizations as well as E&P organizations preparing for operations in new regions may benefit from developing a best practice to ensure quality in their well delivery process. Business mapping can detect challenges that compromise critical elements in operating companies. Suggested improvements can result in increased quality in processes and operations with emphasis on:

- Achieving process consistency,
- Capturing and documenting best practices
- Accelerate project execution
- Create a clear image of responsibilities, key objectives and activities during critical operations.

Aim of Study

The well delivery process is defined as the set of key activities performed by the drilling department from receiving the request to drill from the field development team until the well is closed out and handed over to production (Figure 1.1).

Due to the sensitivity of the data presented, the two operating companies are kept anonymous. Throughout the study the operator on the Norwegian Continental Shelf is consistently referred to as the Operator on the Norwegian Continental Shelf (ONCS). The operator in the Middle East is consistently referred to as Operator in the Middle East (OME).

This study will analyze the WDP of an operating company located in the Middle East. Findings are then compared to a similar WDP analysis of an operating company on the NCS.

The study will point out similarities and differences that affect the WDP and make suggestions that aim to improve the WDP of the OME. Suggestions include lessons learned from the NCS. A general strategy for how to improve the well delivery process will also be proposed.

Opportunities and challenges facing the regions as they prepare for the future are addressed using a PESTEL-analysis. This is presented in the last part of the result chapter.

Structure of Assignment

This Master Thesis is linearly structured and divided into ten different chapters. A summary of the structure of assignment is presented in Table 1.1. Contextualization of the different topics in this assignment in Figure 1.2.

The study starts with a general introduction of the problem statement, purpose of study and structure of assignment.

As a basis for the study, chapter two elaborates on the current and predicted demand of fossil fuels and the role it plays to meet the growing demand for energy. The information is based on recent Energy Outlook publications. Chapter two also present relevant topics for the current and future E&P industry, e.g., energy markets and the price of oil, costs of upstream activities and limited availability of qualified personnel. At the end of chapter two the necessity of continuos improvement in the E&P industry is emphasized.

Chapter three establish the theoretical framework by introducing business mapping, implications of business mapping and business models. A section on key performance indicators and benchmarking is also included. Data and information used in the analysis part is collected based on theory presented in this chapter.

The methodology used is presented in chapter four. The chapter contains the research architecture and a presentation of the research method and tools used.

The well delivery process is defined and presented in chapter five. Included in the presentation is stages in a well delivery process and common tools used to ensure process quality. Chapter six presents information about the two cases that are studied. It gives background information about the energy regions where the two operating companies are located; the Norwegian Continental Shelf and the Middle East. The chapter aim to provide the reader with relevant information about the two operating companies, their approximate size and areas of focus.

Chapter seven presents the results, i.e., it present and compare the WDP analysis of the OME and ONCS. The chapter also present suggested improvements in the WDP of the operator in the Middle East, which include suggestions based on lessons learned from the ONCS and benchmark studies. Future opportunities and challenges are compared using a PESTEL-analysis, i.e., an analysis of common relations and challenges in the the regions, as well as description of unique challenges in the two regions.

Chapter eight discuss the research architecture, methods used and results. The conclusion is presented in chapter nine. Suggestions for future work is presented in chapter ten. Chapter eleven contain appendices. The chapter sections elaborate on relevant topics presented in chapter two, three, five and six.

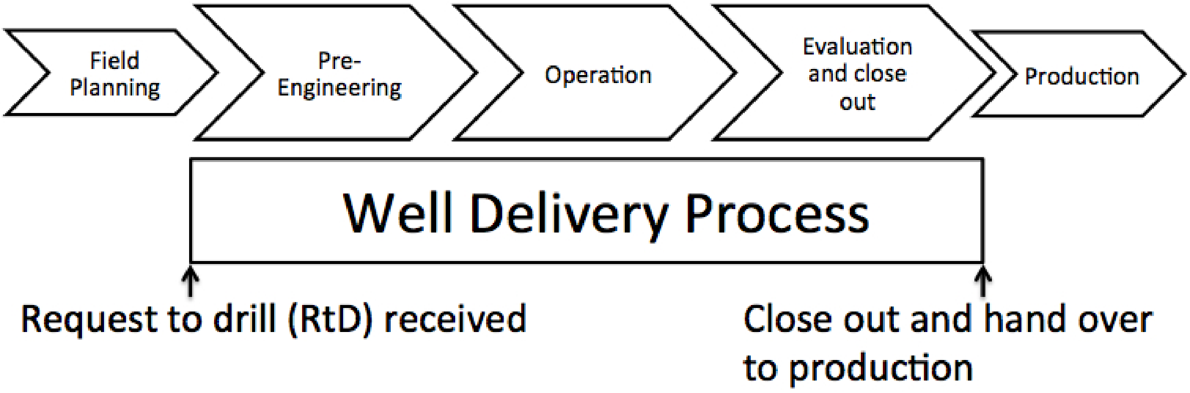


Figure 1.1: The WDP that the study aim to improve is limited from Request to Drill (RtD) to close out hand over to production.

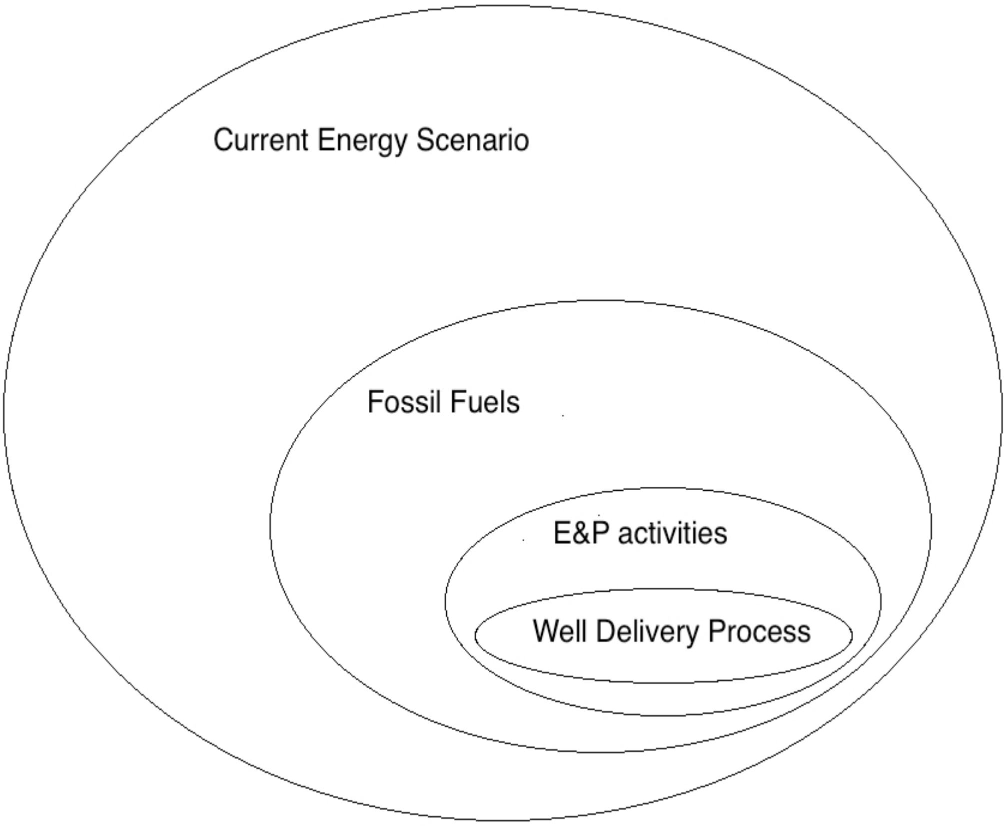


Figure 1.2: Contextualizing main topics included in the assignment.

Structure of Assignment

Chapter	Goal	Purpose
2. Energy Today and Upstream Concerns	Present the current energy demand, the role of fossil fuels and relevant upstream concerns	Visualize the role of the current petroleum industry and elaborate on current supply and demand for energy. The chapter also present global industry challenges, e.g., volatile oil prices, low supply of personnel and the necessity of improvement.
3. Theoretical Background	Give an introduction to relevant theory and methods used	Provide a framework and introduce key concepts that is used frequently in the study.
4. Methodology	Present research methods used	Provide a framework and establish the basis on which the research is conducted.
5. The Well Delivery Process	Introduce and define the WDP	Give a presentation of the well delivery process and common tools used in the WDP.
6. Case Presentation	Introduce the two energy regions and operating companies	To give a better understanding of differences between the two cases and operating companies.
7. Results	Present the results, analysis and other relevant information	To analyze the well delivery processes and present results in a structured manner according to the content of the problem statement.
8. Discussion	Discuss central elements of the study	Discuss methodology, the analysis and discussion in the previous chapters.
9. Conclusion	Present a conclusion based on results and discussion	To present the conclusion and highlight the most important elements of discussions and results.
10. Future Work	Present suggestions for future work	To suggest future work that can improve the WDP and increase the efficiency in drilling and well operations. Other suggestions for future work are also presented.
11. Appendices	Elaborate on relevant subjects	To provide further information on relevant subjects and present examples that are more indirectly related to operating companies in the oil and gas industry and the well delivery process.

Table 1.1: Summary of content in study, including chapter goals and their purpose.

2 Energy Today and Upstream Challenges

This chapter provides a brief introduction to the current energy scenario presented in recent publications by international energy agencies and energy companies. The chapter aim to visualize the current role of petroleum industry and the role of hydrocarbons in the future.

The oil price has an effect on the entire oil and gas industry. The chapter therefore briefly discuss the oil price and recent political factors of relevance. The importance of reasonable priced oil and the Norwegian contribution to stabilize the oil price is also presented.

The last sections present important subjects that operating companies in the E&P industry has to emphasize, i.e.:

- The challenge of rapidly increasing costs
- Scarcity of qualified personnel
- The necessity of continuos improvement in the industry

The high level of cost and scarcity of qualified personnel was recently addressed by the Norwegian Minister of Petroleum and Energy. The Minister stated that companies in the E&P industry should increase focus on these two topics and characterized them as the two main challenges for the industry in the years to come (Ree, 2012).

Further information about the current global energy scenario and scarcity of qualified personnel is provided in appendices.

2.1 The Current Energy Scenario

The latest prognosis presented by the International Energy Agency predicts a significant growth in demand for energy. According to the New Policies Scenario[1] in their World Energy Outlook 2011, the demand for energy is expected to increase by 30% from 2011 to 2035. The increase in demand is driven by an expected average annual growth of 3.5% in the global economy and an increase in the global population by 1.7 billion people. After the economic crisis in the global community in 2008, the short time economic

[1] The International Energy Agency and their New Policies Scenario predictions is based on existing government policies and implementation of declared policy intentions

growth predictions became more uncertain. Still, the result of the recent recession has only a marginal effect on the long-term trend. Figure 2.2 show how IEA's predictions are supported several energy companies and agencies - all predicting future growth in energy consumption from 2010 to 2030. As a result of the increased demand for energy an energy paradox has emerged:

The global energy consumption as of 2012 is not sustainable and future predictions show no sign of improvement in the form of reduction in consumption. It is therefor important to focus on research to develop renewable energy sources and methods to mitigate climate gas emissions.

However, energy availability is critical to lift populations in development countries out of poverty. To meet the predicted increase in demand during the next two decades the only realistic solutions include an increase in use of fossil fuels. Unfortunately, this will also lead to an increase in climate gas emissions

It is important to dampen the energy consumption to mitigate climate gas emissions and support a sustainable use of energy. Simultaneously, it is important to increase the production of energy to reduce poverty and enable large populations access to electricity and clean water.

Increase in population and growth in the global economy are the two most powerful catalysts for increased demand for energy. Since the 1900 the global population has increased by a factor of 4, the real income has increased by a factor of 25 and primary energy consumption has increased by a factor of 22.5. In 2010, the growth in global energy consumption reached 5.6% - the highest rate since 1973 (Figure 2.1)(BP, 2011).

Production of electricity and the transport sector are the two most energy demanding sectors in the world today. The transport sector is most important for the predicted growth in demand for energy and due to limited alternatives for oil as a transportation fuel and subsidizing of oil in many countries the demand for oil is inelastic[2] demand for oil. Figure 2.9 show how the transport sector currently account for 52% of the total primary oil demand globally and how it is predicted to account for approximately 60% in 2035. Other oil consumption sources are the oil used in the generation of power, the petrochemical industry and oil used for heating purposes (Norwegian Ministry of Petroleum and Energy, 2011[3]). The demand for oil, not including biofuels, is expected to rise from 87 million barrels per day to approximately 99 million barrels per day in 2035 (International Energy Agency, 2011[2]) (BP, 2012).

2.1.1 The Role of Fossil Fuels

Fossil fuels are of paramount importance and vital to bridge the gap between energy supply and demand. Today, the total share of energy from fossil fuels is at approximately 81%. Even though the share of fossil fuels in global primary energy consumption is expected to decrease, fossil fuels are still predicted to account for 75% of the energy

[2]An inelastic demand for a good means that changes in price have a relatively small effect on the quantity of the good demanded

by the end of 2030. Predicted future trends suggest that fossil fuels will have a market share of about 25% each, with non-fossil fuel groups having a market share of 6-7% each (Figure 2.3). Fossil fuels will play an important role in supplying the global community with energy and predications suggest that fossil fuels will contribute with approximately 64% of the growth in energy during the next two decades. (BP, 2012).

Renewable energy sources are believed to experience a more rapid growth throughout the next couple of decades, with a growth rate of approximately 8.2% per year. However, due to the rapidly increasing energy demand from of non-OECD countries, predictions indicate that fossil fuels will account for approximately 75% of the worlds total energy supply in 2030. Figure 2.13 depicts how the energy demand from non-OECD countries is believed to be the main driving force behind an increase in energy demand from both fossil and non-fossil fuels. The market share of oil is currently at 32% and the share of coal and gas is approximately 28% and 22% respectively.

The easy available crude oil sources have been harvested and companies are more and more forced to turn their focus towards complicated and costly sources to meet rising demand. The IEA (2011) predicts that the production of conventional crude oil, the biggest component of oil supply, will remain at a relatively constant level at approximately 85 million barrels per day before it declines to around 68 by 2035. To compensate for the expected decline in production from existing fields an additional capacity equivalent to twice the current oil production of all OPEC[3] countries in the Middle East is required (approximately 47 million barrels per day). OPEC member countries listed in Table 2.1. It is expected that the growth in capacity will come from natural gas liquids and unconventional sources of hydrocarbons, with approximately 18 and 10 million barrels per day by 2035 respectively. Biofuels are expected to triple in supply to reach a supply of more than 4 million barrels of oil equivalent per day. However, this is somewhat due to expected subsidies of $1.4 billion by 2035. Iraq expected to increase its oil production the most in the upcoming years, followed by Saudi Arabia, Brazil, Kazakhstan and Canada.

Figure 2.3 show how gas is predicted to be the only fossil fuel that will experience an increase during the next two decades. The use of natural gas to produce electricity through gas and steam turbines is one of the main driving forces behind this increase. The three other energy sources are expected to increase their share of total energy supply from their current level of 3-5% each. To meet the predicted growth in gas demand by 2035 an increase equivalent to three times the current gas production in Russia is needed, i.e., a significant increase in gas production will be necessary. Fortunately the current global resource estimate is sufficient to supply this demand, which is predicted to reach 5.1 trillion cubic meters in 2035. This is 1.8 trillion cubic meters more than the current demand.

The International Energy agency (2011[3]) has stated that global uncertainties affecting the energy sector can provide natural gas with the opportunity of reducing global emissions of greenhouse gases and pollutants through replacement of other fossil fuels,

[3]OPEC stands for the Organization of the Petroleum Exporting Countries currently consisting of twelve member countries in Table 2.1

e.g., hard coal. Gas are especially of interest for growing regions such as China, the Middle East and India, which are regions that to a large extent will determined the expansion of gas use during the next 20 years. Gas can provide energy security and the back-up capacity needed to complement the variable capacity that comes on-line power generation. Gas was also mentioned in the aforementioned presentation by Thina m. Saltvedt at Norskehavskonferansen 2012. Natural Gas was most likely one of the future substitutes for oil, partly due to a lower price per barrel of oil equivalent (Figure 2.8).

Another important factor with regards to future demand for energy is how the global demand for liquids is expected to increase by 16 million barrels per day, to exceed 103 million barrels per day by 2030. Liquids include oil, biofuels and other liquids. Future increase in supply to meet the growth in demand is expected to be met by OPEC. However, supply from non-OPEC members are expected to increase by approximately 5 million barrels per day, primarily due to growth from US and Brazilian biofuels, Canadian oil sands, deepwater discoveries in Brazil and US shale oil. It is believed that this will offset a continued decline in a number of mature provinces (BP, 2012).

2.2 Oil Price and the Norwegian Contribution

Factors Affecting the Oil Price

International relations and political instability affect the cost an availability of energy. As depicted in Figure 2.4, political conflicts have created several peaks in the oil price throughout history, e.g., during the First Persian Gulf war between Iraq and Iran in the 1980's and the Persian Gulf War between U.N. coalition forces and Iraq in 1990.

A more recent example of a dispute elevating prices on crude oil significantly is the announced US sanctions on entities dealing with Iran and the EU embargo on oil imports from Iran (Nasr, 2011). Iran export approximately 2.5 million barrels of crude oil per day, with around 1.63 million barrels going to Asia and 0.75 million barrels per day going to Europe. The announced sanctions are a respond to what is believed to be a nuclear arms development program in Iran and aim to reduce Iran's income from oil export and starve the program of funding (Greene, 2012). The conflict is viewed as the greatest single uncertainty in the current global oil market and might result in Iran stopping all marine traffic through the Strait of Hormuz, where approximately 1/5 of global oil supplies passes (17 million barrels of oil equivalent per day). Iran has also threatened to retaliate against oil producing neighbor countries if they increase their production and oil export as a result of increased demand.

The situation is monitored carefully as it amongst other things influence the availability and price of crude oil (Castle and Cowell, 2012)(Reuters, 2012). The Deputy Executive Director in the International Energy Agency (IEA), Richard Jones, stated that it is expected that Iran will increase sales to other non-OECD[4] countries at dis-

[4]OECD is short for Organization for Economic Cooperation and Development. OECD is an international organization helping governments tackle the economic, social and governance challenges of a globalized economy and has 34 member countries (Figure 2.6).

counted prices. Jones also stated that the IEA, an organization which Norway joined in 1975, will act if the market is unable to reallocate supplies in a crisis, referring to the use of emergency oil stocks (International Energy Agency, 2012).

In february 2011 Iran decided to suspend oil exports to French and British companies, bringing the WTI oil for march delivery up to $105.21 on the New York Mercantile Exchange - the highest price since May 5, 2011 (Hafezi, 2012). Figure 2.5 show the development in oil price from November 2010 to March 2012 and is a good example of how volatile the oil price is.

In addition to the aforementioned conflict involving Iran, several other incidents during this period have influenced the oil price. The arabian spring following the revolution in Libya combined with the earthquake in Japan in early 2011 boosted the oil price to a level of approximately $128 USD. Contrarily the IEA release of oil from emergency stocks and a weaker growth outlook in the middle of 2011 lowered the oil price.

However, political issues and natural disasters are just some of the factors affecting the oil price. Other important factors include:

- Current supply. If supply goes down, the price goes up.
- Current oil reserves, including volumes available in refineries. Refinery reserves are easy accessible and can be released to reduce the oil price.
- Oil demand estimates from the Energy Information Administration (EIA).

Fair Prices and the Norwegian Contribution

High oil prices especially affect oil importing countries, as the price they have to pay for energy increase. Oil importing countries include growing economies like China, Japan and India. The International Energy Agency (2012) estimated that total global gross domestic product (GDP) related to oil expenditures was approximately 5% in 2011. This is the highest percentage since the economic recession in 2008. Developing countries depending on oil import are today facing price ranges of approximately $100 USD per barrel - almost five times the price OECD countries had to pay at a comparable stage of development, experiencing an oil price of $22 USD per barrel adjusted for inflation (International Energy Agency, 2011[2]). The oil import bill for less developed countries has increased to approximately $100 billion USD in 2011, a growth of about 400% in ten years (Figure 2.7).

Fairly priced oil is of benefit for developing countries dependent on importing oil. These countries generate income for producing countries and will contribute to a higher rate of investments in the oil industry. On the 28^{th} of March 2012 Ali Naimi, the minister of petroleum and mineral resources in Saudi Arabia, wrote an article in the Financial Times stating that Saudi Arabia will act to lower the soaring international oil prices. Mr. Naimi emphasize how high oil prices will have a negative effect on emerging economies and poor nations. Saudi Arabia previously tried to lower the recent high oil price and calm the oil market by ramping up their production and increasing supply, but the result has not been significant and the oil price is still high (Tonhaugen, 2012). In recent time there have been rumors of the kingdom lacking ability to increase oil supply on a short term basis to make up for lost production from other regions (Sanati, 2012). However, the minister proclaims that Saudi Arabia has a significant buffer and a capacity far beyond the current level of demand, i.e., an increase in oil export (oil supply) from Saudi Arabia is possible (Naimi, 2012). If this is true or only an attempt to calm the markets is unknown. Saudi Arabia's role with regards to stabilizing the oil price markets is significant as the kingdom holds the most of the worlds spare production capacity of the global oil industry (Bias, 2012). Saudi Arabia's crude oil production capacity is depicted in Figure 2.10.

Norway is number eight on the list over biggest net exporters of crude oil with a total production surplus of 87 million tonnes (International Energy Agency, 2011[2]). The role of Norway's as an oil exporting country is important as it is one of the few countries that bring political stability into the global oil market. This was emphasized by senior macro analyst at Nordea Markets Thina M. Saltvedt during a presentation in Stjrdal on the 8^{th} of March, 2012. Among the fifteen biggest oil producing countries in the world, only Norway and Canada are considered politically stable, i.e., Norway contribute in keeping oil markets and prices stabile. At times when global spare capacity of oil is low (no buffer) and political uncertainty is more prominent than usual, the oil from Norway is important in order to calm the markets. An example of a conflict that will elevate oil prices is if western countries led by USA and Israel decide to use military force on Iran. Norway is also a net exporter of gas to Europe.

2.3 Increasing Cost of Upstream Activities

The upstream capital cost index (UCCI) and the upstream operating cost index (UOCI) indicate the average cost level of geographically diversified E&P-projects. Both the UCCI and the UOCI index has increased significantly since year 2000, experiencing rapid incline around year 2006. Since year 2000, the UOCI and UCCI has increased by 80% and 120% respectively, i.e., the cost for operators to supply oil to global markets has become more expensive (Figure 2.16)(Figure 2.15). The trend of more expensive upstream services is somewhat confirmed by companies in the oil service business making more money than ever before. In 2011 Baker Hughes more than doubled their earnings compared to 2010 ($1 739 billion in 2011 versus $812 million in 2010) and Maersk Drilling delivered a 24% rise in net profit in 2011 compared to 2010 (Hobbs, 2012) (Lehane, 2012). The subject of an increasing cost level in the petroleum industry has been given attention by the Norwegian Ministry of Petroleum and Energy, with emphasis on factors such as increased rates on rigs, labour and equipment as explanatory variables (Norwegian Ministry of Petroleum and Energy, 2011[3]). Upstream costs are important as they can determine whether or not operators determine to develop a field or not. The increase in development costs is clear when looking at the breakeven prices in submitted plans for development and operations on the NCS. Since 2004 the breakeven price for new field developments has tripled, moving from approximately NOK 100 per barrel of oil equivalent to more than NOK 300 per barrel oil equivalent in 2009 (Figure 2.17).

The average oil price has increased during the later years and seem to have settled at around \$100 USD per barrel. However, upstream costs have increased simultaneously and compensated for operators increase in income due to high oil prices.

Scarcity of suitable drilling vessels combined with high demand globally have resulted in high day rates on drilling rigs and ships. The IHS Petrodata Day Rate Index confirms the high demand of deepwater drilling rigs. The index monitor the offshore drilling fleet globally and track day rates and utilization statistics. In February 2012, the IHS Petrodata Deepwater Rig Day Rate Index moved above 800 points for the first time since 2009, indicating a continued trend of high demand for semisubmersible rigs and drill ships operating in deep waters worldwide (IHS, 2012). The index is charted relative to the average market day rate in 1994 of 100 points. Figure 2.18 show how the utilization of deepwater drilling vessels worldwide have been extremely high the since the beginning of 2009, with an average level of 97-99%, resulting is extremely high day rates on deepwater drilling vessels. The current day rate record is held by the drill ship Deepwater Champion. The ship is owned by Transocean and is equipped to operate in water depths of approximately 3650 meters, with a drilling depth capacity of 12 200 meters (Rigzone, 2012). In 2008 Transocean and Exxon Mobile agreed on a five year contract for operations in the black sea. With an estimated day rate of \$650 000 USD it is the most expensive drilling vessel in the world (Økland, 2011). The current record on the NCS of \$610 000 USD is held by the drilling vessel West Navigator owned by North Atlantic Drilling. The rig is able to handle water depths of approximately 2280 meters and a drilling depth of 10 680 meters (Rigzone, 2012[2]).

In March 2012 the worldwide drilling rig fleet was at 825 units, with 665 of these under contract (worldwide fleet utilization of 80.6%)(IHS, 2012[2]). Figure 2.19 show how the utilization rate of rigs worldwide has been high level since 2008, with an average worldwide fleet utilization fluctuating at around 75 to 90%. According to the rig locator on Offshore.no there are 31 rigs active on the NCS (as of April 2012). The leasing contract on many of these rigs expire in 2012. It is not certain that they will continue there work here after the contracts expire.

The drilling process should be emphasized by operators as it has great potential with regards to cost reduction. Drilling costs accounted for 47% of the total investments in discoveries and fields on the NCS in 2010. In 2009 the rig costs amounted to more than NOK 15 billion (Norwegian Ministry of Petroleum and Energy, 2011[3]). Drilling of wells is the single largest component in petroleum activities on the NCS and is a significant contributor to the total costs of improved recovery measures (Figure 2.20). Drilling of development wells is of great importance for future production and reserve growth. Drilling of development wells on existing fields can potentially increase the proven reserves significantly. The subsurface of mature fields is often mapped in greater detail than during drilling of early development wells, i.e., additional resources can often be recovered due a better understanding of the reservoir. However, there are also factors that can make development drilling complex and time demanding, e.g., difference in pressure regimes and number of existing producers.

The rig market is vulnerable for changes in the price of oil. From 1980 to 1989 an average of 64 drilling rigs were disengaged worldwide for every one dollar decrease in real oil price, with 50 of these 64 located in North America. For every one dollar of increase in oil price from 1999 to 2006 a total of 29 rigs were engaged. Based on data from 1980 to 2006 it is discovered that the exploration industry, which is of paramount importance for reserve growth and supply of energy, respond asymmetrically to rising and declining in real oil prices. A one dollar decrease in real oil prices will disengage more drilling rigs compared to the elevated number of engagement of drilling rigs from one dollar increase in real oil prices (Omowumi, 2007).

2.4 Scarcity of Qualified Personnel

Access to qualified personnel is one of the biggest bottlenecks[5] in the E&P industry today. During Norskehavskonferansen 2012 (Norwegian Petroleum Conference) the subject was given a great deal of attention. Several articles in the media have highlighted the need for qualified personnel in the E&P industry (Houston Business Journal, 2012) (Kaspersen, 2012) (Kaspersen, 2012[2]) (Halvorsen and Ellingsen, 2012). The topic was also mentioned during the World Petroleum Congress in 2008, where the age distribution in the industry was discussed and described as alarming. The average age in E&P companies is approximately 50 years and among the oldest in any industry. In 2005 it was estimated that 40 to 60% of aging employees would retire within five years (Riemer, 2008). The age range of working professionals in an oil and gas company versus the age range of working professional in a typical technology focused company is depicted in Figure 2.21. The distribution show that a significant part of personnel in the oil and gas industry is between 35 and 54 years old. Analyzing the in data in Figure 2.21 further it is evident that number of experienced employees between 60 and 65 is approximately the twice the number of young professionals between 20 and 29. An important factor with regards to age is also that the experience per person in the group between 60 and 65 is far greater that the experience per person in the group between 20 and 34. This makes the personnel problem even bigger, i.e., the discrepancy between future demand and supply of industry knowledge an know how in the oil and gas business is big will continue to grow in the years to come. The combination of a global society demanding more energy and a predicted scarcity of qualified personnel to develop major E&P projects is unfortunate.

There have been recent reports of scarcity of qualified personnel in the oil and gas industry. In April 2012 Subsea 7 announced that the company will open a new office located in Oslo. The main office of Subsea 7 is located in Stavanger, but in a press release the company proclaimed that access to a market with skilled personnel were one of the main drivers for opening an office in the Norwegian capital (Tjelta, 2012) (Taraldsen, 2012). The scarcity of qualified personnel in the middle east was also emphasized by Deloitte & Touche (M.E.) in 2011.

[5] A bottleneck is a term describing a situation where the performance or capacity of an entire system is limited by a single or limited number of components or resources

2.5 Necessity of Continuos Improvement

Ripple effects from improvement in the oil and gas industry has great potential that can benefit several. This was exemplified by the Norwegian Oil and Energy minister in 2011.

The minister stated that a 1% increase in recovery rate on the NCS would create an additional value of $59 billion USD - approximately half a state budget.

The second example is related to the effect of improving lifetime of giant fields on the NCS. The work of expanding the Ekofisk and the Eldfisk fields in the southern part of the North Sea is expected increase recovery by more than 470 million barrels of oil equivalents by 2028 (Marshall, 2011[2]).

Difference in CO_2 Emissions

China has over the past years increased their production of hard coal significantly to meet the increasing demand for energy as the domestic energy intensive industry grows. In 2010 China accounted for 51.1% of the global production of hard coal (Figure 2.14). Coal is a major source with regards to CO_2 emission, which is reflected on the top ten list of emitting countries of 2009 where China is the biggest actor, followed by USA and India (Figure 2.22). Simultaneously it is important for developing regions to produce energy to develop and experience economic growth. Alternative energy sources and more fuel efficient alternatives must therefore be emphasized. Increased recovery rate of oil and gas can help mitigate the use of hard coal to produce energy, which will be beneficial with regards to emission of CO_2. Figure 2.23 show how both crude oil and natural gas has a lower emission of CO_2 per kWh than other bituminous coal. Natural gas has 48% lower emission of grams CO_2/kWh than cole used for cooking and a 55% lower emission than other bituminous coal (International Energy Agency, 2011[4]). A continued focus on technology development and improving the way operations are carried out can result in an increase in global recovery of hydrocarbons, increased supply of energy and lower CO_2 emissions. Companies mainly operating within the oil and gas industry has also contributed to solutions that are of benefit in other industries, e.g., using geosteering and directional drilling techniques to drill for water and equipment, experience and technology from the oil and gas industry to build windmills in harsh environments offshore.

Technology Improvement Favoring Operating Companies

The development of mature areas ha new discoveries on the NCS is an example of how focus on technology and development of new methods for discovery can give new life to an already established oil and gas region.

Operators and partners in the oil and gas industry has emphasized recovery enhancement and the development in the industry during the past decades has been significant. By investing in research and development (R&D) and avoiding getting stuck in a conventional way of thinking the recovery rate has increased globally, e.g., the 8% increase in recovery rate on the NCS from 1995 to 2009 (from 40% to 48%). A continued development of technology and drilling techniques will allow operators to develop fields in ways previously believed to be impossible.

Methods, technology and techniques developed in an area can also be off benefit in other regions. One of the reasons for this is the global footprint companies in the E&P industry leave behind. BP, Shell, Total, Statoil and ConocoPhillips are operators that do business in all parts of the world. For these companies, efficient flow of information and communication of new technical solutions and ways to increase recovery rate are vital for achieving operational excellence. Some examples of techniques that have had a big effect on the oil and gas industry globally and have helped contributed to increase recovery include improvement in various areas and disciplines are:

- Development of directional drilling (Drilling)
- Rotating drillstring to remove friction (Drilling)
- Gas- water- and chemical injection in reservoirs (Reservoir)
- Simulation tools for optimizing well trajectory and reservoir drainage (Reservoir)
- Gas lift to help lift the well stream so that the operator produce at lower reservoir pressure (Production)
- Implementation of integrated operations to improve operating efficiency and enhance communication across disciplines (Human Resources)

Development of new technical solutions can make previous unattainable resources available and better allocation of resources can make previous unprofitable projects valuable to peruse. Measures to increase operational efficiency can also increase the lifetime of existing fields, which has been known to correlate with improved rate of recovery (an example from the NCS in Figure 2.24).

Improved Allocation of Resources

An important progress made in the oil and gas industry related to allocation of resource is tied to the way day-to-day operations are driven. The development and implementation of integrated operations has improved communication across disciplines and enhanced surveillance of ongoing operations in the E&P industry. Flow and availability of information is of paramount importance as it is the foundation on which decisions are made. In a business where uncertainties are large and investment costs huge information that can improve decision making is extremely valuable. Integrated operations has provided better allocation of key resources. An improvement in exploitation of human resources is important area to focus on for companies in the oil and gas industry.

Inefficient operations can have significant negative consequences as oil and gas fields are dependent on profitability to defend its existence and avoid decommissioning. Declining production occur due to reduction in reservoir pressure as hydrocarbons are recovered. Implications are lowered production rate, reduced income and an increased importance of efficient operations to attain profitability. Business mapping have the potential of detecting inefficient operations, reduce operational expenditures (OpEx) and subsequently contribute to increase a fields lifetime. Lowering a fields OpEx can extend a fields tail production[6] and increase rate of recovery because costs are lowered and the field is made profitable for a longer period of time.

[6]Tail production is a term used to describe the final stage of the declining production phase

OPEC Member Countries		
Algeria	Iraq	Qatar
Angola	Kuwait	Saudi Arabia
Ecuador	Libya	United Arab Emirates
Iran	Nigeria	Venezuela

Table 2.1: Members of the Organization of the Petroleum Exporting Countries (OPEC) as of April 2012 (OPEC, 2012).

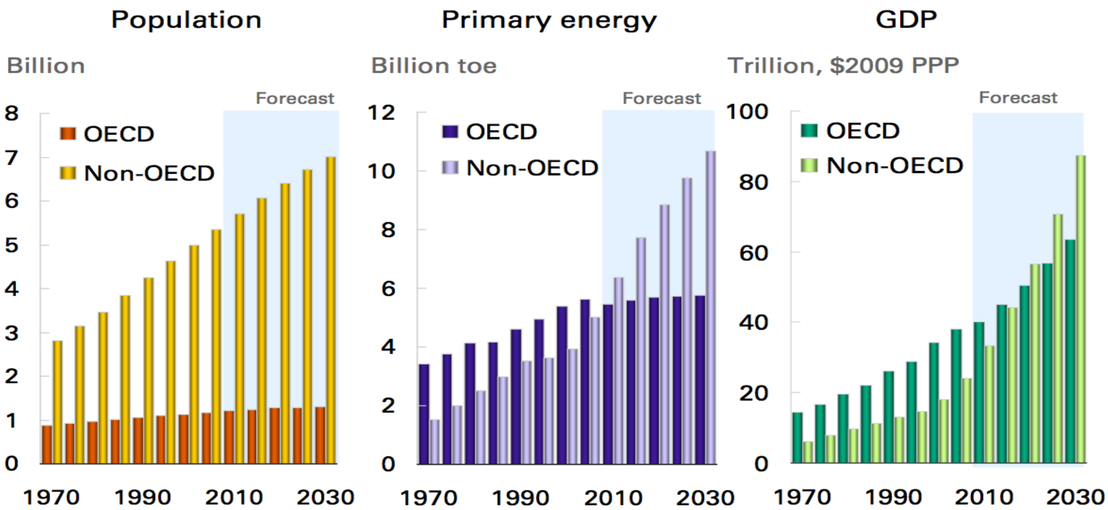


Figure 2.1: Graphs showing past and predicted growth in global population, primary energy need and Gross Domestic Product (GDP) from 1970 to 2030. Population and income growth are considered the main driving forces behind the demand for energy (BP, 2011).

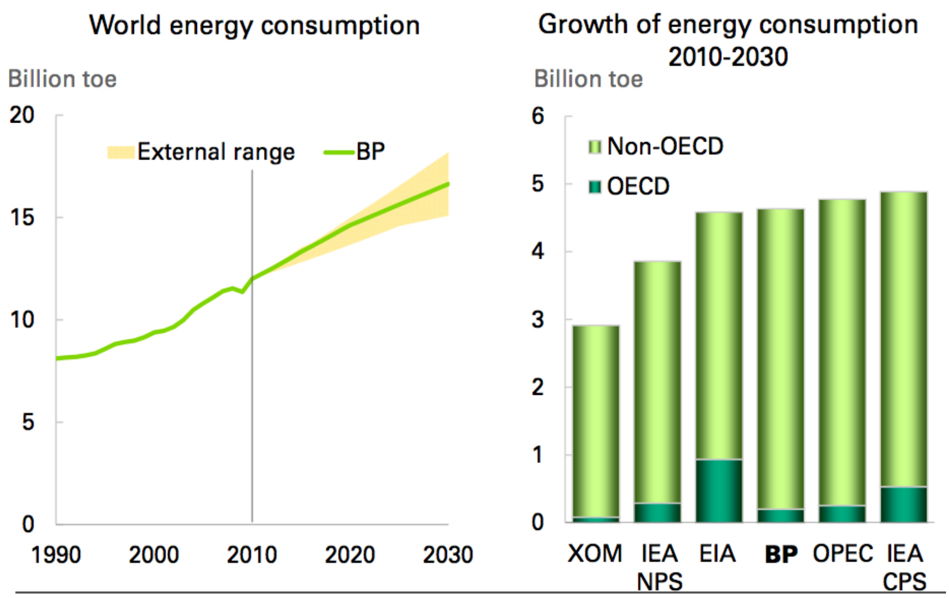


Figure 2.2: Graphs showing past and predicted growth in energy consumption. The columns to the right show predicted energy consumption from 2010 to 2030 put forward by several agencies and companies. In all scenarios non-OECD countries are predicted to be the main driver behind the increase in consumption (BP, 2011).

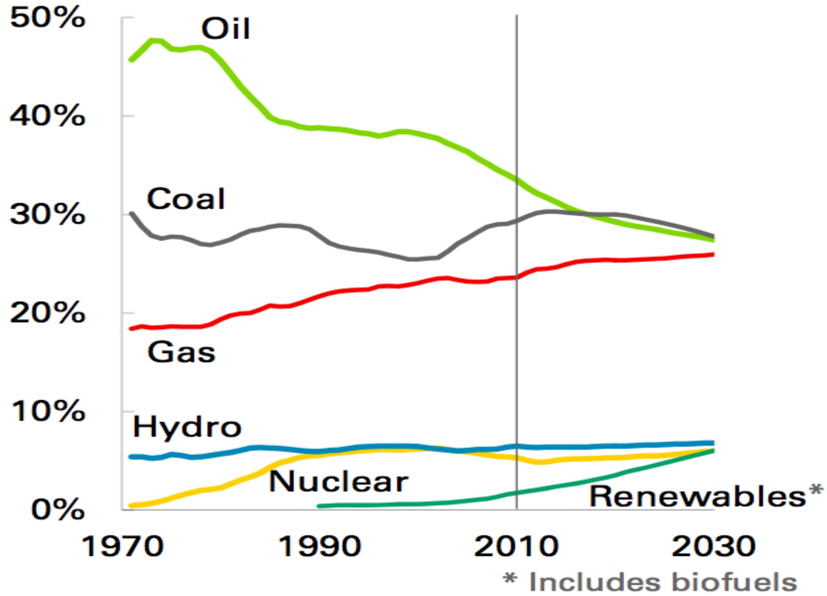


Figure 2.3: The graph show past and predicted growth in shares of world primary energy from 1970 to 2030. The market share of fossil fuels is approximately 26-28% each and non-fossil fuel groups having a market share of 6-7% each within 2030 (BP, 2012).

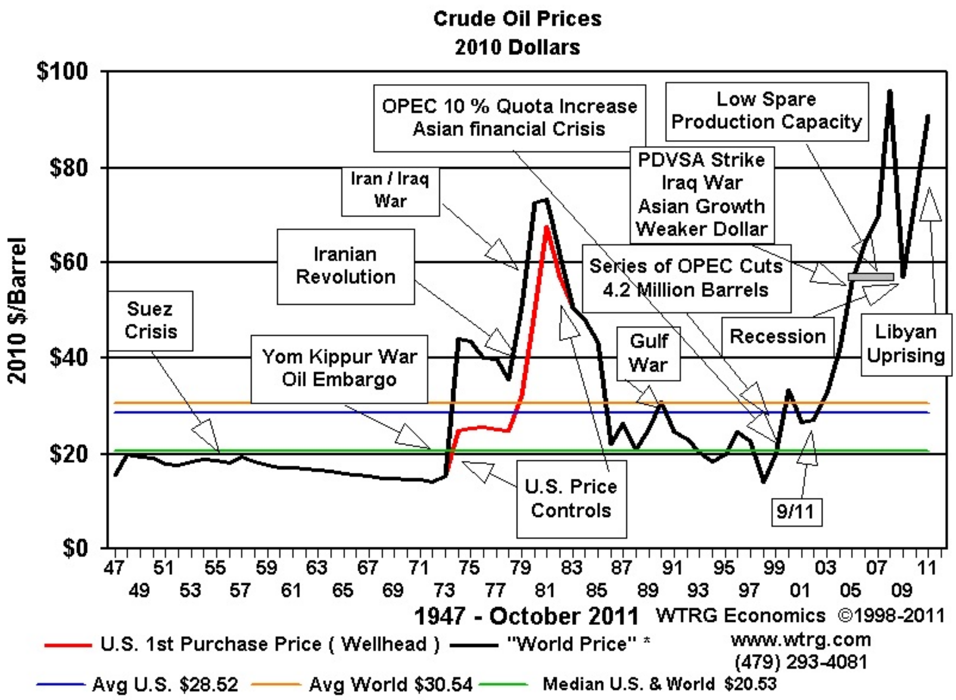


Figure 2.4: Oil Prices have fluctuated throughout the years and are influenced by macro economics and politics, amongst other things (West Texas Research Group (WTRG) Economics, 2011).

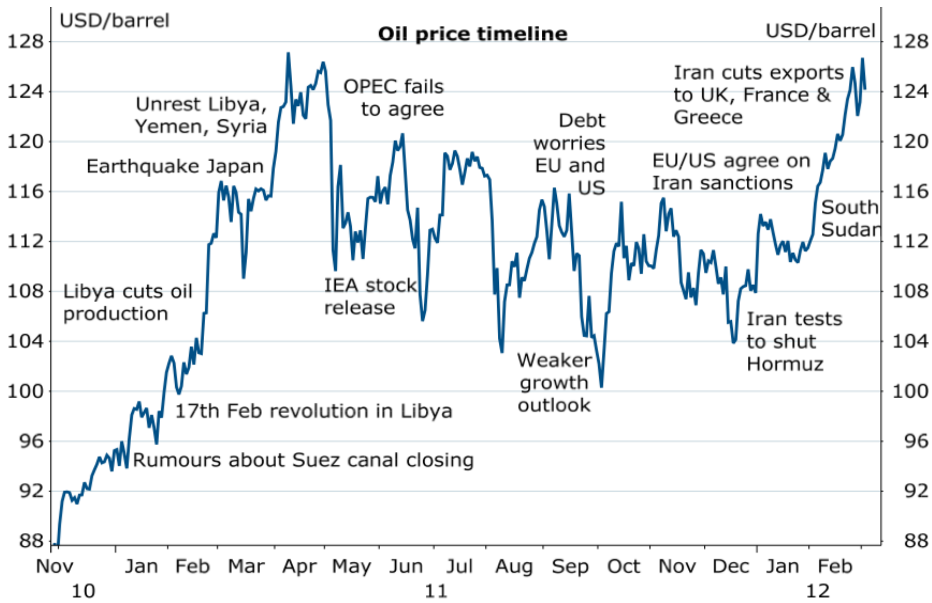
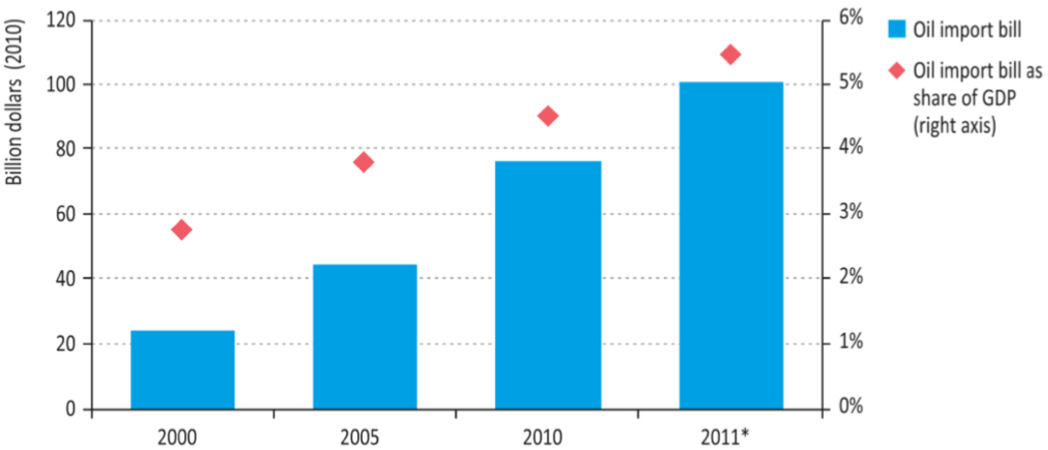


Figure 2.5: The recent development in the oil price clearly show how macro economics influence the oil price on a shorter term as well (Saltvedt, 2012).

Current OECD Member Countries (March, 2012)

Australia	**France**	**Korea**	**Slovenia**
Austria	**Germany**	**Luxembourg**	**Spain**
Belgium	**Greece**	**Mexico**	**Sweden**
Canada	**Hungary**	**Netherlands**	**Switzerland**
Chile	**Iceland**	**New Zealand**	**Turkey**
Czech Republic	**Ireland**	**Norway**	**United Kingdom**
Denmark	**Israel**	**Poland**	**United States**
Estonia	**Italy**	**Portugal**	
Finland	**Japan**	**Slovak Republic**	

Figure 2.6: Organization for Economic Cooperation and Development (OECD) member countries as of March 2012 (OECD, 2012).



*** Estimated, assuming an average oil price of $100 per barrel.**

Figure 2.7: Oil import bills in net importing less developed countries have increased by approximately 400% during the last decade. Note that oil import bills as a percentage of GDP are at market exchange rates in 2010 dollars (International Energy Agency, 2011[2]).

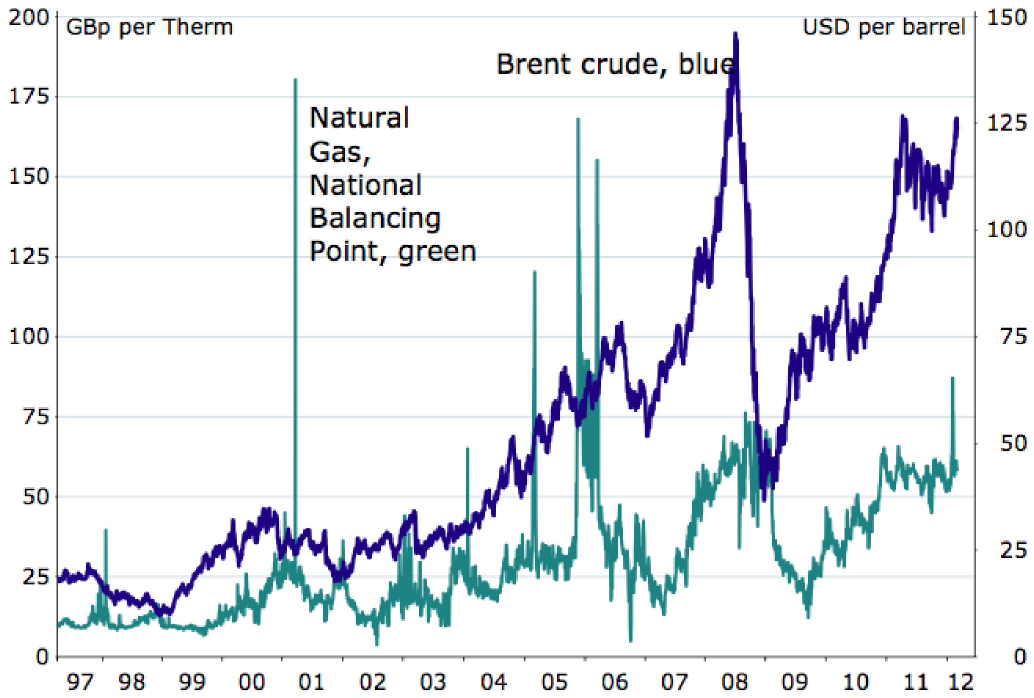


Figure 2.8: Gas and oil price in USD per barrel (Saltvedt, 2012).

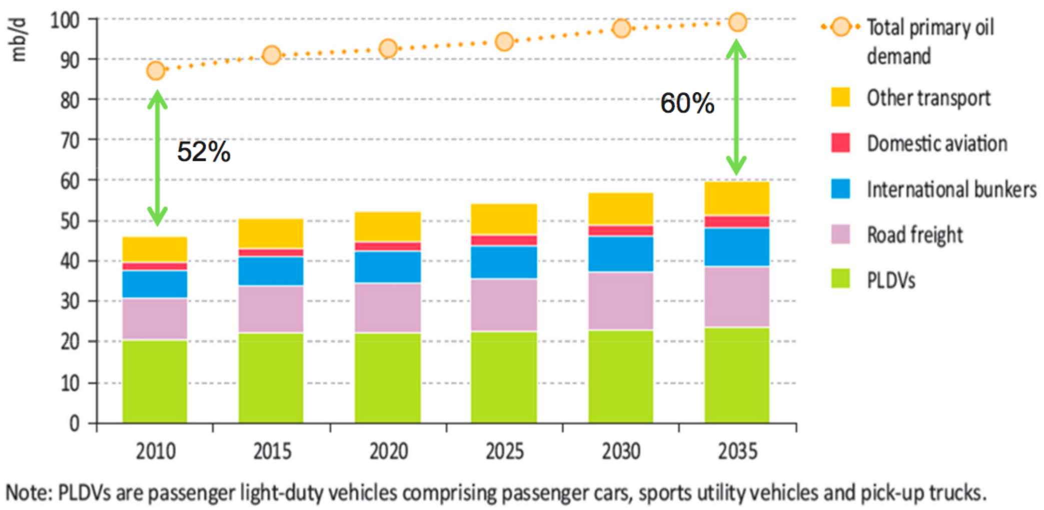


Figure 2.9: The transport sector part of total world primary oil demand is currently at 52% and is predicted to increase to approximately 60% by 2035 (Saltvedt, 2012).

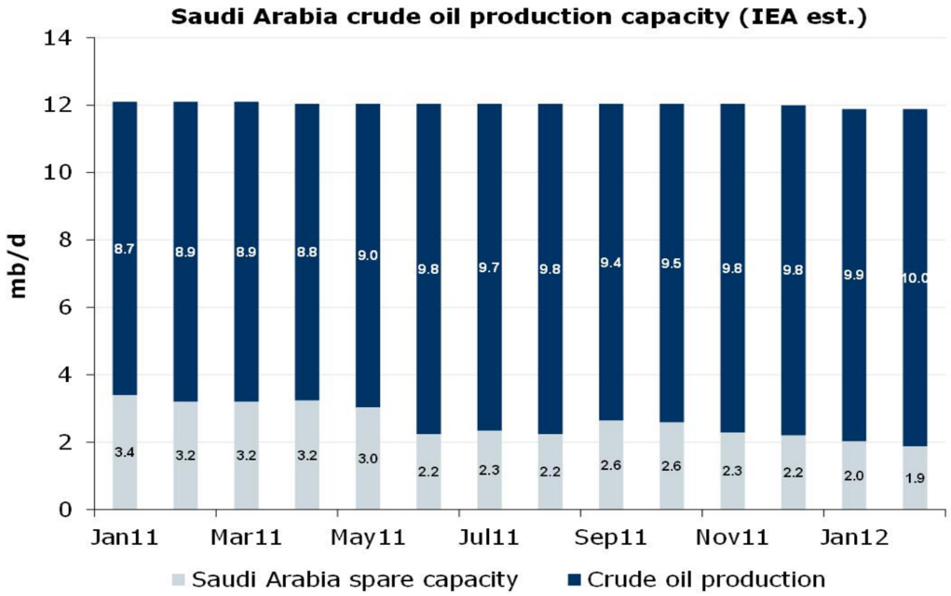


Figure 2.10: Saudi Arabia crude oil production capacity from January 2011 to January 2012 (Tonhaugen, 2012).

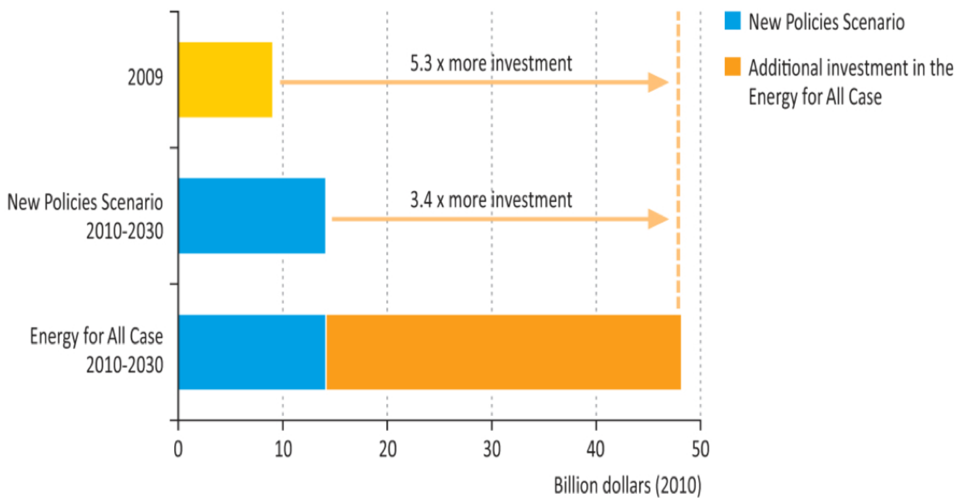


Figure 2.11: Average annual investment to achieve modern energy access by scenario. The calculated the cost of achieving the Energy for All Case is $1 trillion USD (International Energy Agency, 2011[2]).

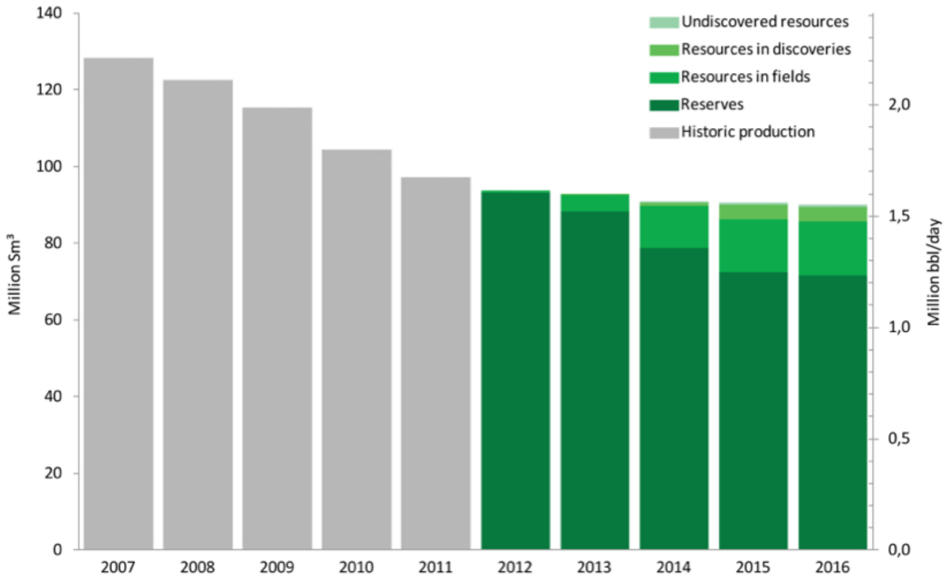


Figure 2.12: Domestic oil production in Norway 2007-2016, distributed by maturity. 98% of the oil production in the period is expected to come from fields currently in operation or fields approved for development (Norwegian Petroleum Directorate, 2012).

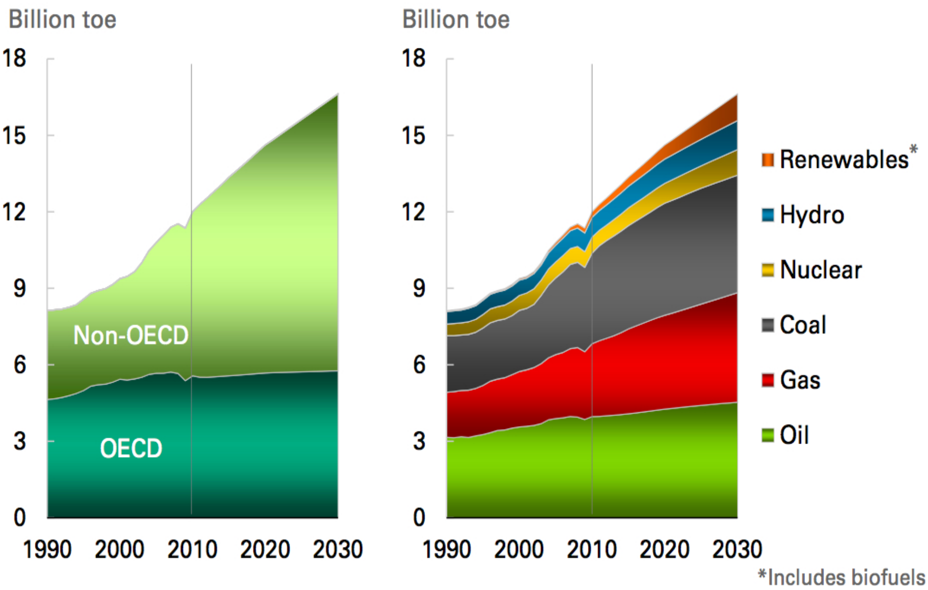


Figure 2.13: Non-OECD countries are predicted to be the main driving force behind increasing demand for energy until 2030 (BP, 2012).

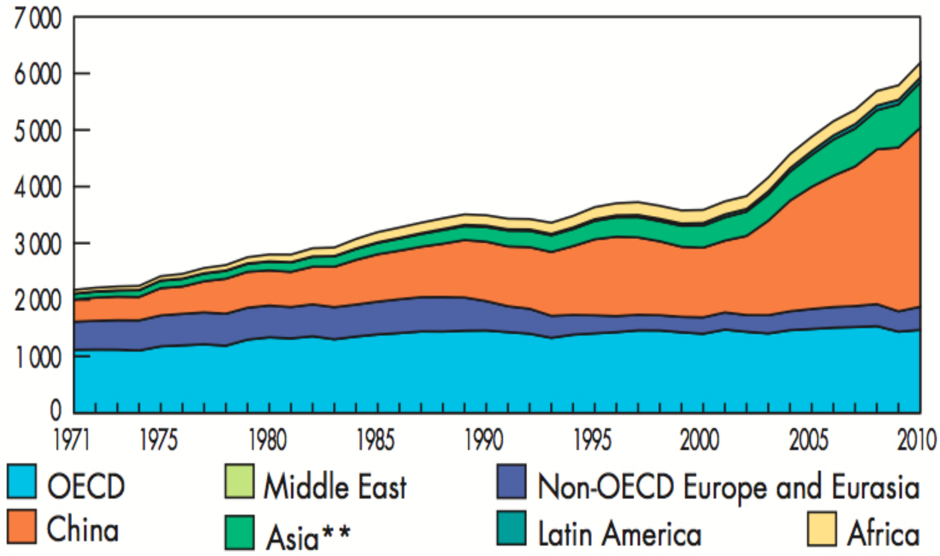


Figure 2.14: Development in global production of hard coal by region from 1971 to 2010 (in million tonnes). In 2010, China accounted for 51.1% of the global production. *Includes recovered coal. **Asia excludes China. (International Energy Agency, 2011).

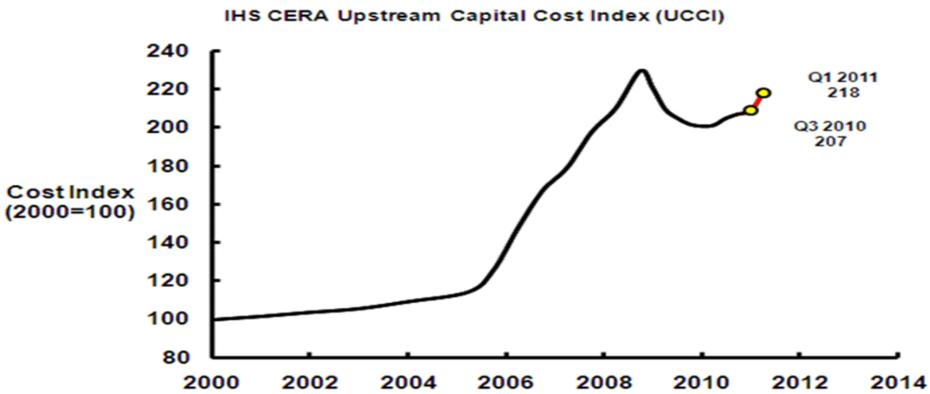


Figure 2.15: The Upstream Capital Costs Index is constructed on the basis of costs of equipment, facilities, materials, and personnel used in the construction of a geographically diversified portfolio of 28 onshore, offshore, pipeline and LNG projects. It is similar to the consumer price index (CPI). It provides a clear, transparent benchmark tool for forecasting a complex and dynamic environment (CERA, 2011).

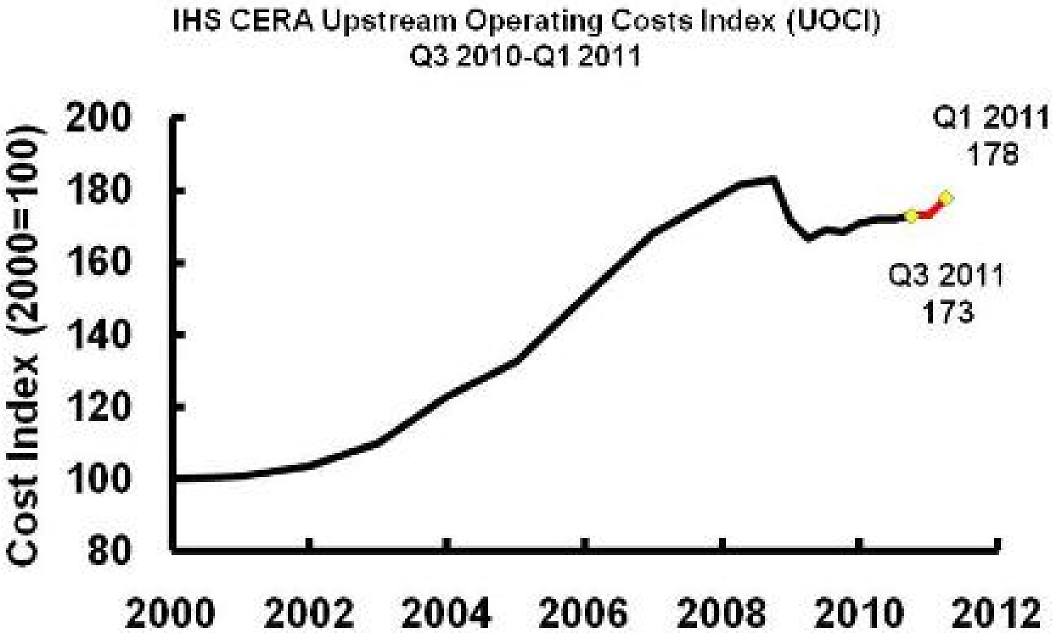


Figure 2.16: The Upstream Operating Costs Index increased by 2 % during the Q3 2010- Q1 2011 period. The increase was driven by market fundamentals and personnel costs, in addition to markets that are impacted by high oil prices, e.g. chemicals and transportation (CERA, 2011).

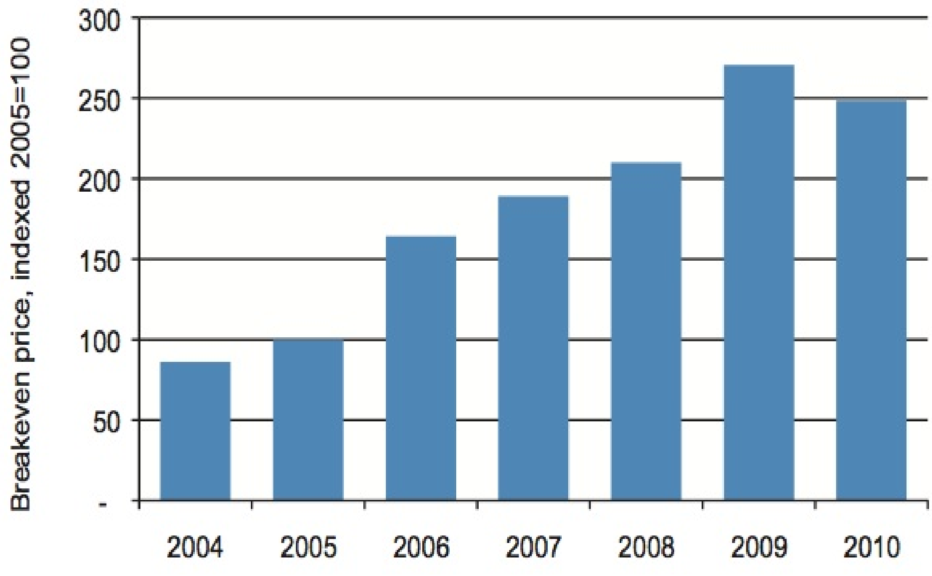


Figure 2.17: Breakeven prices for plans for development and operation from 2004-2010. The prices are volume weighted (Norwegian Ministry of Petroleum and Energy, 2011).

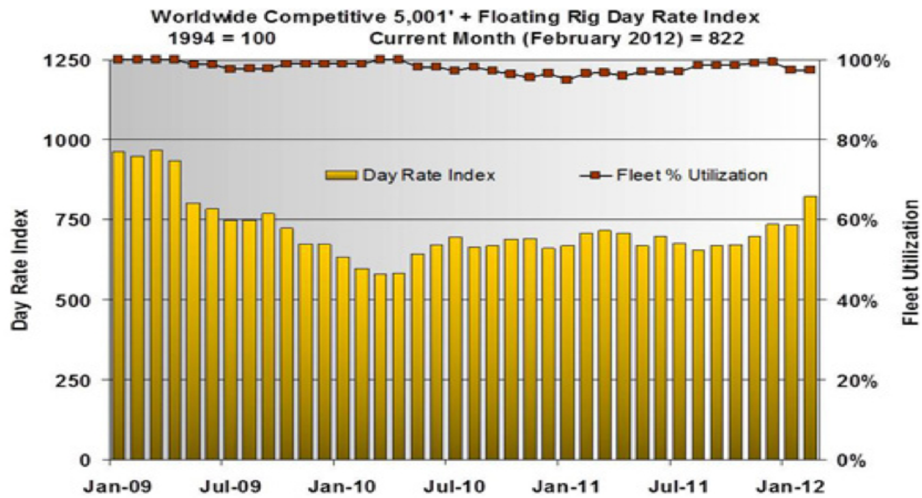


Figure 2.18: Worldwide competitive floating rig day rate index (2009 to present). The IHS Petrodata Day Rate Index monitor the competitive mobile offshore drilling fleet day rates and utilization, which has been extremely high since the beginning of 2009. In February 2012, utilization in the deepwater category (more than 5001 feet) was 97% (IHS, 2012).

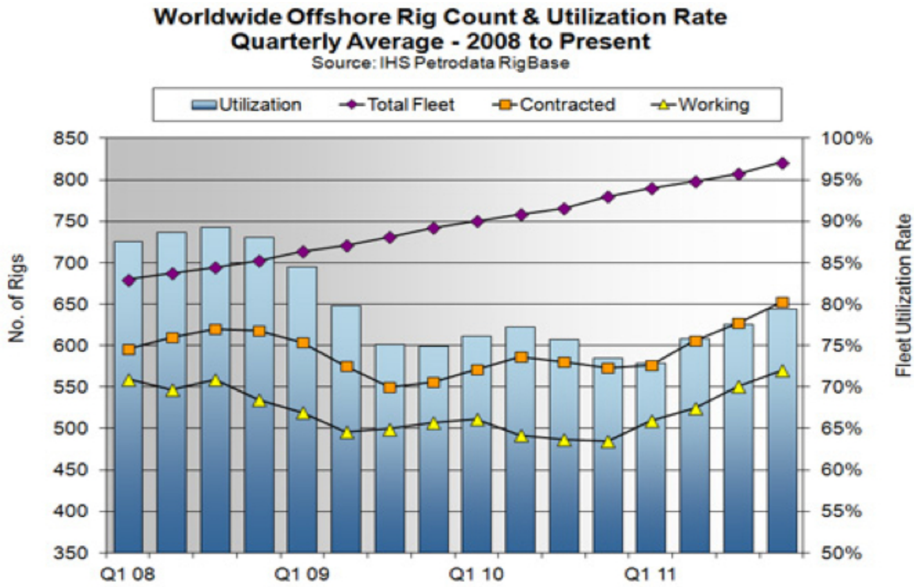


Figure 2.19: Worldwide offshore rig count and utilization rate (2008 to present). The the IHS Petrodata Weekly Rig Count is derived from data compiled on a daily basis by IHS global team of rig market analysts and reporters. The utilization rate of rigs worldwide has been high since 2008, with an average worldwide fleet utilization ranging from 75-90% and a current utilization of 80.6% (665 of 825 rigs under contract) (IHS, 2012[2]).

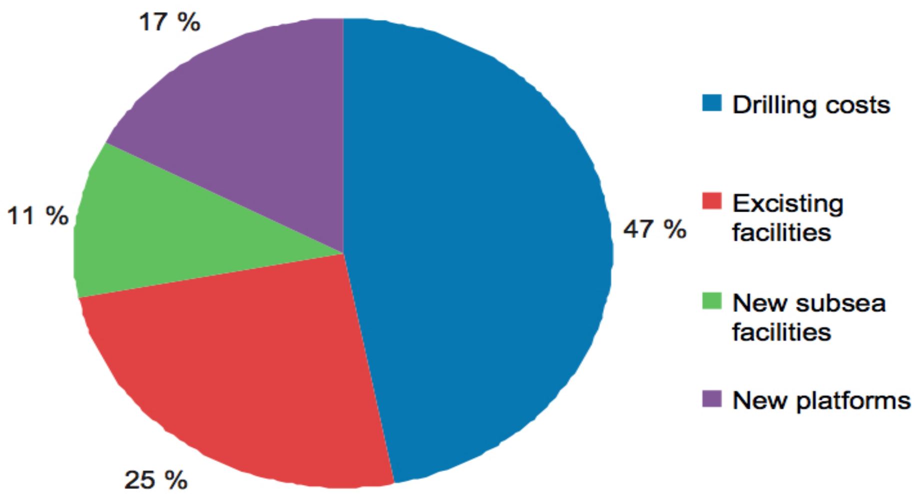


Figure 2.20: Distribution of investments in discoveries and fields on the NCS in 2010. Drilling costs are a significant part of the costs to improve recovery and in development and exploration (Norwegian Ministry of Petroleum and Energy, 2011[3]).

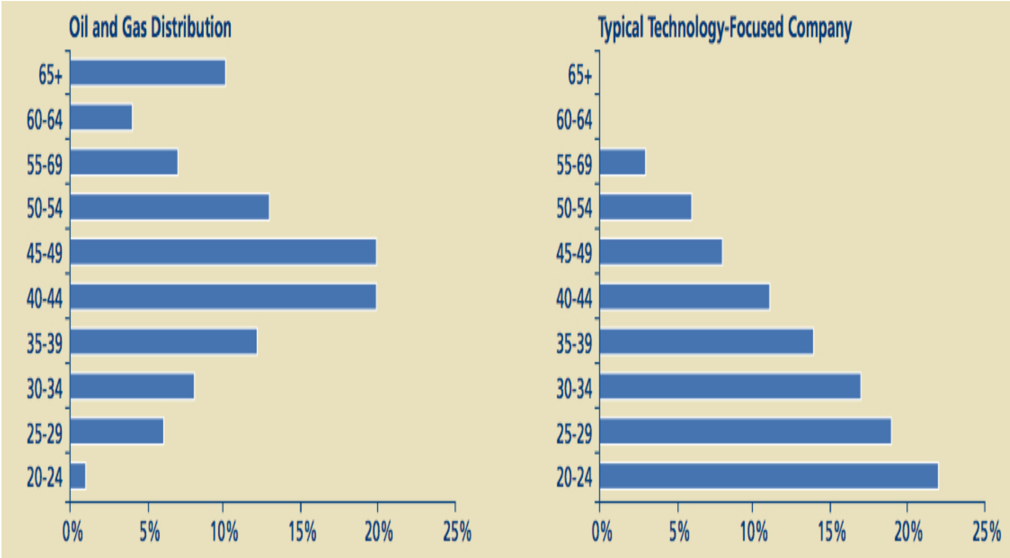


Figure 2.21: Age distribution of personnel in the oil and gas industry compared to a typically technology-focused company as of 2005 (Sampath and Robinson, 2005).

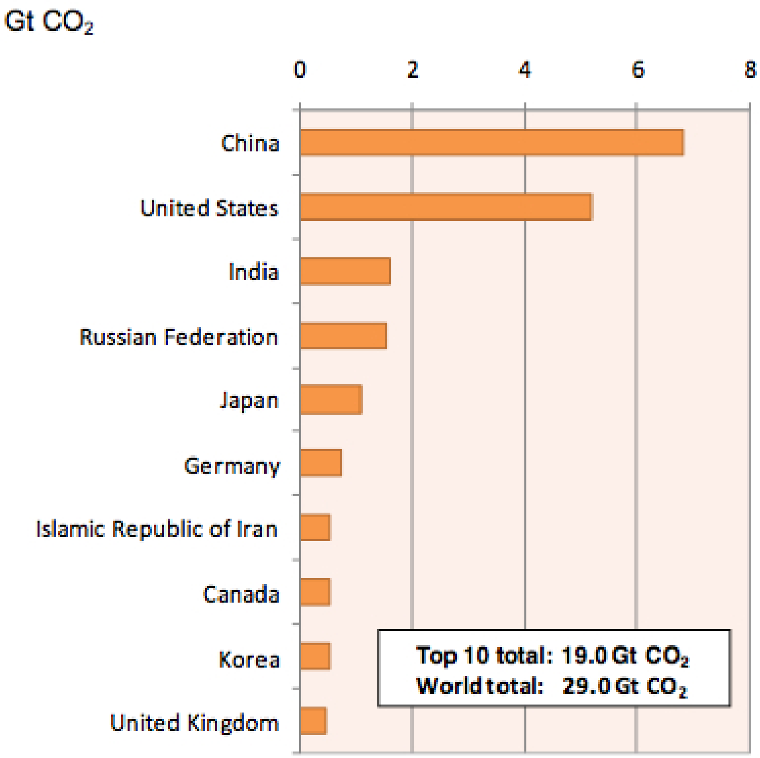


Figure 2.22: Top ten CO_2 emitting countries in 2009. Together these countries accounted for approximately 66% of the world CO_2 emissions (International Energy Agency, 2011[4]).

Fuel	g CO_2 / kWh
Anthracite *	835
Coking coal *	715
Other bituminous coal	830
Sub-bituminous coal	920
Lignite	940
Patent fuel	890
Coke oven coke *	510
BKB/peat briquettes *	500-1100
Gas works gas *	380
Coke oven gas *	390
Blast furnace gas *	2100
Oxygen steel furnace gas *	1900
Natural gas	370
Crude oil *	610
Natural gas liquids *	500
Liquefied petroleum gases *	600
Kerosene *	650
Gas/diesel oil *	650
Fuel oil	620
Petroleum coke *	970
Peat *	560
Industrial waste *	450-1300
Municipal waste (non-renewable)*	450-2500

Figure 2.23: CO_2 outlet per pram kWh for various fuels. The values represent average grammes per kWh of electricity and heat produced in the OECD countries from 2007 to 2009 (International Energy Agency, 2011[4]).
*Represents under 1% of electricity and heat output in OECD and are considered less reliable.

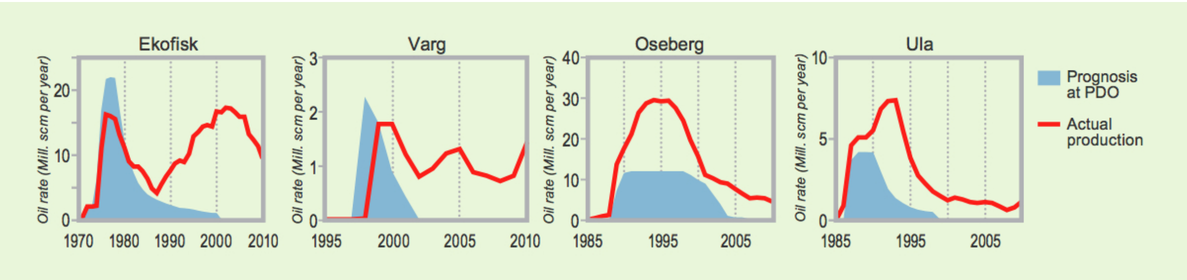


Figure 2.24: Production development and original production prognosis for Ekofisk, Varg, Oseberg and Ula show how increasing the lifetime of a field often correlates with more of the oil and gas in place being recovered than expected in the original prognosis (Norwegian Ministry of Petroleum and Energy, 2011).

3 Theoretical Background

This chapter presents relevant literature and background theory. The chapter aim to give the reader an introduction to important elements and concepts in the assignment, i.e., business maps, benchmarking and key performance indicators (KPI's). The theoretical introduction provides a foundation and a framework for the qualitative analysis, which is central for results and discussion (Figure 3.1).

Further information on benchmarking, business models and performance indicators is provided in appendices.

3.1 Business Mapping and Business Models

By developing business models that are fit for purpose and respecting the individuality of each project, companies are able develop roadmaps when executing projects. These taylor made business models can learn from lead performers and adapt best practice procedures to achieve efficient operations. Business models based on best practices can help an operator obtain consistency in planning, execution and deliverance of projects. Business models can also optimize the entire project phase and shorten the time spent on a project. Co-existing with the aforementioned benefits is the potential of securing a better documentation and sharing of best practices from previous to future projects (Evensen and Rasmussen, 2011[1]).

3.1.1 Process Maps and RACI matrices

Business maps and models often consist of several sub-categories containing important processes. Effective processes are essential for organizational development as they enhance the flow of important information and facilitate for a high level of coordination. Curtis et al. (1988) describe how communication and coordination often are the main reasons for project teams failing to reach their objectives, i.e., communication and coordination are vital for team success (Ancona and Caldwell, 1992)(Dougherty, 1992). Problems related to coordination and communication often occur in interdependent teams working on complex problems included in complex projects - a common way of working in the oil and gas industry. To mitigate such problems procedures and rules are often inserted, e.g., (Picolli et al., 2004). Process maps and RACI matrices are useful to visualize and contextualize important aspects and areas of an organization. By using such tools an organization can achieve an increased awareness of responsibilities and accountability, i.e., process ownership. The tools are also useful when analyzing processes and can contribute to increase team efficiency and reveal areas of improvements that can lead to development of a company best practice.

RACI is an acronym used to clarify roles and responsibilities related to an activity. RACI charts are also often used in combination with process maps. The letter R stands for Responsible, while letters A, C and I stands for Accountable, Consulted and Informed respectively. RACI charts make it easier to understand critical elements of an activity, such as central and local roles, accountability (including suppliers). This is especially important in a development phase in order to manage progress and monitor risk and quality (Evensen and Rasmussen, 2011[2]).

A paint job on an ordinary house is an example showing how the RACI approach works. Consider the main actors as the owner of the house hire a contractor to do the paint job. The bullet points below list the RACI-elements according to necessary activities:

- The Contractor

  Hire the workers and ensure that the job is done properly

  - Accountable (A) and Responsible (R)

- The Workers

  Do the required set of processes and sub-processes

  - Responsible (R)

- The House Owner

  To be consulted regarding choice of colors and informed when work is done

  - Consulted (C) and Informed (I)

A RACI template can be developed as the RACI letters are distributed throughout the different process owners. The template show how an activity can be divided into several sub-processes with numerous roles and responsibilities. It also show the distribution of RACI letters for each role and sub-process. Figure 3.4 is an example of a RACI-way of documenting how an activity is performed in an E&P company. Also stated in the RACI table in Figure 3.4 are roles and responsibilities related to the activity.

Due to the benefits drawn from consistency and clarity in the planning and execution phase, work processes and process maps are used extensively in the E&P industry. Process maps clarify the order of which different processes in an activity should be performed, describe activities and the ones executing the activities, in addition to related KPI's, review points, etc. Examples of important organizational processes in an E&P company often visualized in process maps are business planning processes, procurement processes, well engineering and design processes, rig contract management processes and well delivery processes. Figure 3.5 show a typical RACI chart that is a part of a completion service provider plan.

Properly documented work processes include information necessary for continuos improvement and consistent success in the execution phase, e.g., description of key processes, important process elements, description of models and their cyclicality, governing guidelines, related documentation and data. By clearly defining work processes an organization can achieve consistency in project execution across the entire organization.

Vandenberg et al. (1999) studied the impact of high involvement work processes on organizational effectiveness. The effectiveness was based on the organizations return on equity and its turnover, and investigated 49 organizations. It was found that high involvement processes influenced the organization both indirectly and directly as a result of positive influence on employee morale.

In April 2012 the Norwegian Ministry of Petroleum and Energy was given a report that contained twelve suggestions meant to contribute to an enhanced oil recovery on the NCS. KonKraft, which constructed the report on request from the ministry, can be described a cooperation arena for important actors in the Norwegian oil and gas industry, e.g., LO, Oljeindustreiens Landsforening (OLF), Norsk Industri. This report emphasized the importance of processes and proclaimed that a significant cost reduction could be achieved through standardization of work processes and equipment. 16.7% of the suggestions in the report were related to standardization as a tool to save costs and achieve more cost efficient project execution, confirming the potential of high quality work processes in the oil and gas industry and organizations in general (Bjørsvik, 2012).

Companies in the oil and gas industry can experience significant benefits from reviewing existing processes. Analysis can be conducted by utilizing process maps and established RACI matrices visualizing important processes. The result is potentially establishment of a best practice for key activities.

3.1.2 Organizational Change: Challenges and Experiences

Change is not always associated with a positive outcome and is seldom met by encouragement if it yields in a significant impact on the way a company and its employees are used to act, think and function. In fact, most humans are change averse - especially if routines and past experiences have resulted in fair outcomes and results. This is very much the case for the E&P industry, which historically have generated high incomes for asset owners. Focus have therefore not always been on efficient working processes and operations and the industry is known to be somewhat conservative when dealing with changes, even though the focus on implementing new technology and cost efficiency have increased through times of marginal fields and periods of low oil price.

The success of business modelling and process mapping rely on overcoming several challenges. Past experience by Evensen and Rasmussen (2011) and Ziff and Baciagalupo (2002) have shown that focusing on how things are now and how well they work, as opposed to future potential is a common mentality. If a company decides to develop a business map, its employees and managers need to understand why an approach like this is chosen and how it works. Before activities are initiated, participants must therefore understand and accept that it require time, participation and effort. The issue regarding transformation of innovative idas into strategy and becoming a part of the operation is an example of strategic challenge, while required resources to complete the business model is an example of a political challenge. It is also important to be aware of the ideological challenge as a result of the "this is how we do things" type of mentality; the need for the company to embrace the need for pursuing internal efficiency and also exploring new strategic options. A criteria for success is that the company do the organizational commitment required. This is done by allocating needed resources and focusing on flexibility, prioritizing the processes and expecting adjustments and alignments.

Lessons learned by Rasmussen and Evensen (2011) are many. By expecting a difference in company-perception between new managers and employees as a result of their different background and experiences, recognition of challenges have proven to become more easy. By using visualization of common goals and opportunities as a tool, managers and employees are brought together on a common platform making it easier for them to work side by side towards common goals. A key point is to secure the involvement of management and key personnel to facilitate the change process and implementation of a lean operation. Integrated planning does not necessarily imply the discovery of the optimal plan and many companies do not retrieve the maximum amount of value from their management systems. This is often a result of viewing the management system as a tool of maintenance rather than a tool of operational change and improvement. Including supply companies and partners (i.e. external partners and original equipment manufactures) when working with assessment of operational opportunities, the flexibility of future process changes are secured.

3.2 Benchmarking

By keeping the company up to date on results of lead performers in areas that are considered important and by developing business models based on best practices, the operator will be better equipped in creating value. Effective and efficient operations and work processes can yield significant positive results are beneficial for all operating companies. Benchmarking can act as a tool, mapping the performance of an operator and compare it to operating peers. The result can be detailed analysis that identify operational areas of improvement leading to a development of a best practice.

In todays market there are numbers of factors which companies are not capable of controlling, with the oil price being the most important one for E&P companies. It has fluctuated throughout the years and the global economy seem to be more volatile than ever. Success of exploration activities and volumes of discoveries are also uncertain variables difficult to control. It is therefore important to take control of economic drivers that can be influenced by the company and make the best of what it is able to have an impact on. Costs that the company is able to manage are mainly resources employed for capital and operations, e.g.:

- Exploration and Development Cost
- Drilling and Completion Efficiency

- Production Rate
- Human Resource Efficiency
- Improvement of Supporting Disciplines

Figure 3.2 depicts different production stages during the lifetime of a field. The rate of production changes significantly during a fields lifecyclye and so do aspects which a company is capable of controlling. In the initial phase ideas are developed, methodologies revised and infrastructure developed. In this phase the rate of production is zero and the potential of efficient and quick development of discoveries in order to recover capital spent is a variable that can be managed. After the initiating phase, the field is set into production; however, the field is still in development and the emphasis is first and foremost to bring production up to a production plateau. In the mid-life of a field production optimization can be achieved through efficient team work and mitigation of operating cost per unit. As as field is becoming older and matures the production rate declines. The focus in this phase should to be on optimizing production and keeping operating costs at a minimum. In addition, it is important to highlight on measures of improving the lifetime of a field from the start of development. To exemplify; on the 16^{th} of November 2011 the project manager for EOR in Petoro, Erik Søndenå, held the presentation *"A New Spring for EOR on the NCS?"* at the SPE member meeting for November in Stavanger. He spoke about challenges related to incorporation of EOR measures during field development. Erik Søndenå pointed out that the main issue is the high initial investment costs and long lead time from initiation of EOR projects to noticeable effects on production rates. This is an issue that especially negative when revising pilot testing of new technologies with an uncertain outcome. He emphasized that a willingness to explore operational paradigms and make long term investment is of paramount importance for enhancing recovery on the NCS.

Benchmarking is used frequently to assure efficient team management and can reveal differences and highlight areas of improvement, both in terms of people efficiency, operating practices, cost efficiency and production maximization (Figure 3.3). Benchmarking is used in several sectors, e.g., healthcare, education and automotive, and defined in different ways. In the paper "Benchmarking- Finding Out What You Really Want to Know" by Helgerman and Jovanovic (2008) several benchmark definitions are described. The Benchmarking Exchange (2012) defines benchmarking as a tool to help an organization improve its business processes by identifying, understanding and adapting the best practices from other organizations. The Benchmarking Exchange describe benchmarking as an activity that aim to find best practice and high performance and then measures actual business operations against those goals.

An alternative definition by Clarke and Goodisman (2000) describe benchmarking as a continuous process of comparison against peers to improve your performance.

Analyzing results are important to achieve improved performance. It is critical to understand why field performance is different to address performance gaps and enter the value adding phase. Companies succeeding in using benchmarking to improve results are aware of the importance of communicating results to field staff and key employees so that they are aware of how decisions impact overall operating cost. It is also important to capture lessons learned and repeat the procedure to reduce cycle time so that performance enhancement is made more effectively. Criteria for successful benchmarking results include sincerity with regards to performance reported by the company and an actively use of benchmarking results to plan and initiate processes to improve operations. Clarke and Goodisman (2000) identified a significant potential for companies participating in benchmarking studies and estimated that companies making an effort improve their operations in the time after benchmarking studies can reduce field operating costs by approximately 5-10%. The study also conclude that benchmarking is an effective tool to determine performance of assets and identify strengths and opportunities for improvement.

3.3 Implications of Business Mapping and Benchmark Studies

Potential implications of the business model approach presented are significant and area of realized benefits widespread. Some implications are easily noticed and have a direct impact on the company, e.g. reduced costs, changes in working structure and less time spent on preparing new projects.

Other effects are however more abstract and difficult to notice. The effect of alignment and how line managers and key personnel can realize the link between their own personal goals and the company strategy is one example. Another one is how collaboration can be increased by highlighting the importance of information exchange across disciplines and companies. The presented approach also investigates areas of improvement in a systematic manner, ideally preparing the company for performance management. This is an area which can have measurable effects and result in increased cost awareness. Project risks[1] related to new operation phases can also be reduced as the approach clarify responsibilities through accountability and documented information flow for all activities.

Areas that have demonstrated their potential by using blueprint technology range from well planning to logistics.

By integrating work processes of geosteering, well planning and directional drilling, the reservoir drainage area can be increased and well trajectory improved. The integrated well planning and execution cover the well design, drilling preparation and downhole operations, in addition to an integrated scheme of how to place the well in the reservoir.

In 2000, Clarke and Goodisman presented offshore and onshore best practice suggestions as a result of an extensive benchmark study. The paper examined costs and methods related to oil and gas operations for nearly 2000 fields located in Western Canada and in the lower US. Best practices offshore included shared boat and helicopter transportation to achieve better results in offshore operations. To reduce unnecessary expenses it was also recommended to emphasize simultaneous support of development

[1] In this context, reduced risk is referred to as absence of surprises

projects and operations. Among onshore best practices in gas areas, compression was presented as a critical area. Throughout the studies a clear trend of operators renting gas compressors was registered. Rental companies proclaim that they are able to run compressors more efficient than operators, however; operators are recommended to own compressors in mature gas fields when pressure decline is predictable and reserves are long lived. The paper also consider management of compressor equipment as an area of improvement for offshore operators. Areas that are critical for high performance include automation to improve combustion efficiency and allow for remote operation.

Well completion and downhole tools are important features which have a large effect on the productivity and stability of the well. It also affect the need of well maintenance and cost of the well. Cooperation and an improved flow of information to assure the optimal type of well completion improve production rates, keep maintenance work to a minimum and lower costs.

Studies performed presented by Ziff and Baciagalupo (2002) exemplify how areas of opportunities can be revealed through business mapping and benchmarking. By examining activities related to lost production (downtime[2]) for a South American operator, it was to revealed that pulling operations contribute with 63% to the total. When examining activities related to pulling operations it was discovered that only 47% was related to the pulling activity, implying that approximately 15% of the time was due to waiting on the actual work. Better operating practices in this area could lead to reduced downtime and costs. An example of how benchmarking can reveal areas of opportunities is demonstrated in Figure 3.7. The figure show unit operating cost versus total annual production in fields located in North- and South America. A large gap between industry leaders and worst performers was discovered when examining medium sized fields (circled), with an unit operating cost difference of $3.5 dollar per barrel of oil equivalent (boe). A trend between well productivity and operating cost is also revealed, showing how well productivity is closely related to operating expenditures. An area which also show a significant difference between business leaders and poor performers is revealed when plotting unit drilling cost of a group of directional drilled wells versus their respective rate of penetration (RoP)(Figure 3.8). The study was based on analysis of 400 wells drilled and completed in an onshore US gas drilling region. It also concluded that efficient and effective drilling and completion programs are vital to an operators success - with drilling and completion contributing to about 70% of total capital spending.

By implementing good practices costs can be reduced and production increased by the reduction of downtime. Costs and operating practice are closely correlated, and past experience have shown that there is a significant potential in using best practices at the right time and in right parts of the company. By identifying and assessing areas of potential through benchmarking and business maps, the gap between industry leaders and poor performers can be reduced (Figure 3.9).

[2]Periods of interrupted production are often referred to as downtime

3.4 Key Performance Indicators

Performance indicators are used in a variety of businesses to measure performance and key parameters. The advantage of measuring key variables is that it makes it easier to demonstrate progress, detect areas of improvement and compare ones result to others (given that the performance indicators are relative and impartial). Key Performance Indicators (KPI's) are widely used in financial reporting to show how a company is performing in various areas, e.g., return on capital, gross domestic product. Examples of important KPI's in banking, petroleum and retail are shown in Table 3.1. Performance indicators are often considered as incentives to enhance performance and as a tool to monitor important processes.

Many KPI's are connected to processes in a company. An example is how the KPI's listed below are tied to the budget preparation process of capital expenditures:

- Process: Budget preparation of capital expenditures
- Related KPI's

  KPI 1: Number of changes required after the budget is finalized

  KPI 2: Variance of the actual budget from the planned budget

  KPI 3: Process time

To get a better understanding of how to govern an E&P company there has been an increasing focus on management approaches aiming to optimize the organizational performance, i.e., performance management to improve business processes and their outcomes (Walburg et al., 2006). Activities in performance management often include KPI's and analysis of information they provide to better be able to achieve important goals. Revenue and customer satisfaction are examples of common KPI's. Performance indicators can transform abstract business goals into concrete elements easy to understand and measure, e.g., "the organization should be emphasize the health, safety and well being of their employees". This goal can be made more concrete through the statement "Serious incidents in the US should be below one during the fourth quarter of 2012", where a related KPI would be "number of serious incidents" and the cohering target being "less than two from July 1. to September 30., 2012".[3] KPI's are effective instruments for governing an organization, as they can easily be monitored, are easy to understand and changes are quickly discovered. (Eckerson, 2010). Using inappropriate KPI's can have a negative effect on performance, e.g., focusing on quantity over quality can result in employees lacking focus on presence of quality in the product or service they provide. Emphasis should therefore be on implementing KPI's that improve key performance areas in an organization (Perjons and Johannesson, 2011).

KPI's are also used to monitor progress in development and other non-financial categories. Shell is an example of a company that have used a variety of KPI's to measure

[3]According to the United States government fiscal year for 2012 the fourth quarter last from July 1. to September 30.

how the company develops with regards to sustainable development. The key performance indicators the operator chose to measure and report on progress in commitments to sustainable development are shown in Table 3.2 (Eccles et al., 2001).

KPI's that might be of interest for the WDP range from planning to process effectiveness and are listed in Table 3.3. Examples of KPI's in the planning are average variation in drilling days versus actual drilling days and number of wells per number of wells planned. In the operations category interesting KPI's are lost time and meters per day drilled. KPI's to measure performance of contractors are hours of critical equipment maintenance, stuck pipe time and HSE-related incidents, e.g., dropped objects and minor personal injuries.

Key Performance Indicators Divided by Industry		
Banking	Petroleum	Retail
Customer Retention	Capital expenditure	Capital expenditure
Customer Penetration	Exploration Success Rate	Store Portfolio Changes
Asset Quality	Refinery Utilization	Expected Return on New Stores
Capital Adequacy	Refinery Capacity	Customer Satisfaction
Assets Under Management	Volume of Proven and Probable Reserves	Similar Store Sales
Loan Loss	Reserve Replacement Costs	Sales per Square Meter

Table 3.1: Examples of key performance indicators that represent key information in the banking, petroleum and retail industry (PriceWaterhouseCoopers, 2007).

Key Performance Indicators	
Category	Description
Economy	• Economic Performance • Return on average capital employed • Total shareholder return • Customer Satisfaction • Innovation
Social	• Respect for people • Critical health and safety data • Staff feelings on how the company respects them • Human rights
Environmental	• Management of environmental impacts • Critical environmental data • Acceptability of performance • Potential impact on climate changes • Greenhouse gas emissions
Governance & values	• Integrity • Staff belief that business principles protect them and encourage them to act with integrity • Reputation • Degree of alignment of business processes with sustainable development principles

Table 3.2: Details of Shell Key Performance Indicators used to report on progress in meeting commitments to sustainable development (Eccles et al., 2001).

Key Performance Indicators Relevant for Analysis of the Well Delivery Process	
Category	Description
Planning	• # Wells drilled / # Wells planned • Average variation in project estimated costs versus actual cost • Year on year action plan variability • % of change requests received for budgeted wells planned to be drilled in the current year • Average variation in actual drilling days versus planned drilling days
HSE	• Personal Injuries • Environment incidents/Volume of discharges • Dropped objects
Finance	• Asset operational expenditures • Cost of new wells & well Intervention • Deviation cost • NOK/meter
Operations	• Invisible lost time • Lost time • Meters/day drilled
Contractor performance	• Down time • Mean time between failure (MTBF) • Efficiency as per contract KPI • Deviation cost • Hours of critical maintenance • Rig availability % of total time • Stuck pipe % of time • Time per job completion/intervention • HSE (serious incidents, dropped objects)
Process effectiveness	• Number of change orders/deviations • Process cycle time

Table 3.3: Details of Key Performance Indicators that are of interest when analyzing a well delivery process.

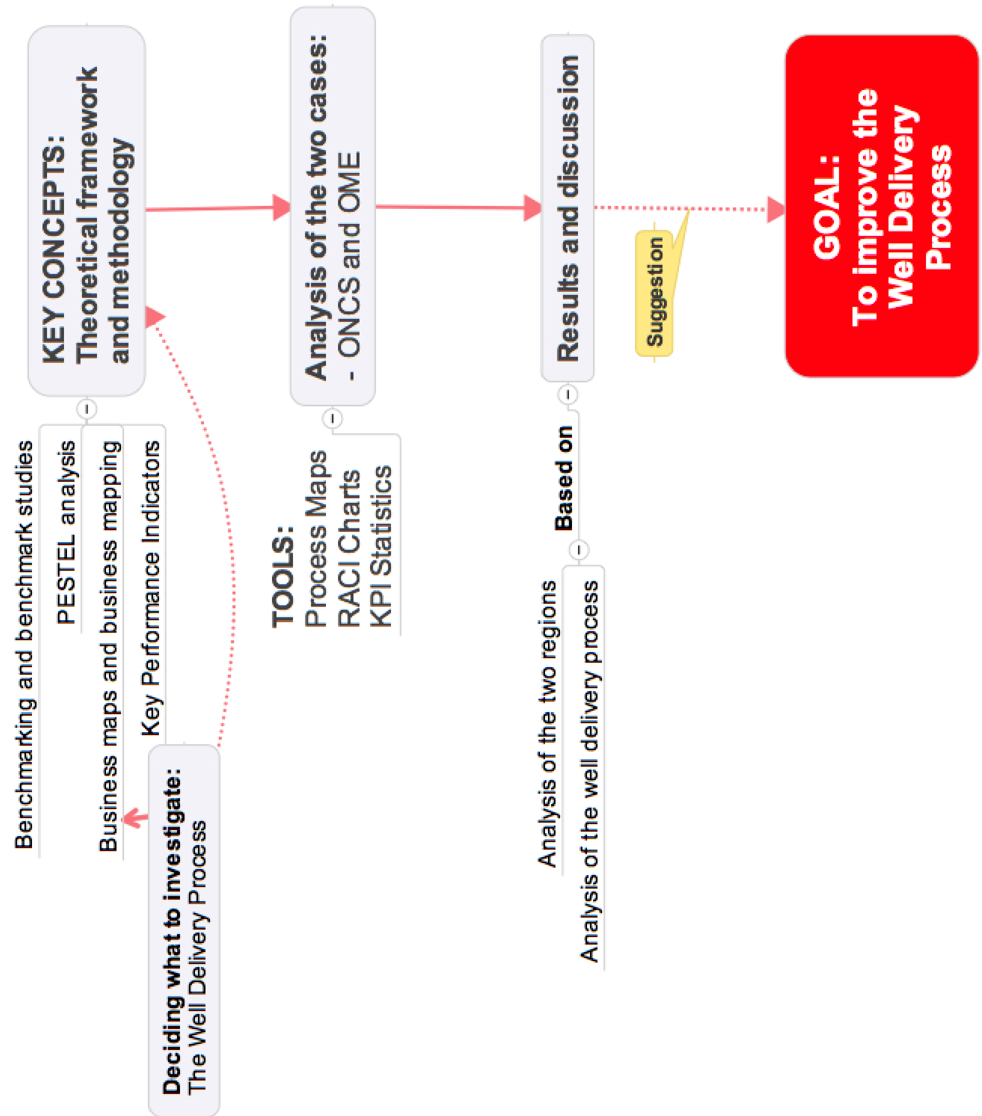


Figure 3.1: Map visualizing how the purpose of assignment is related to theoretical framework, methodology, analysis and results and discussion.

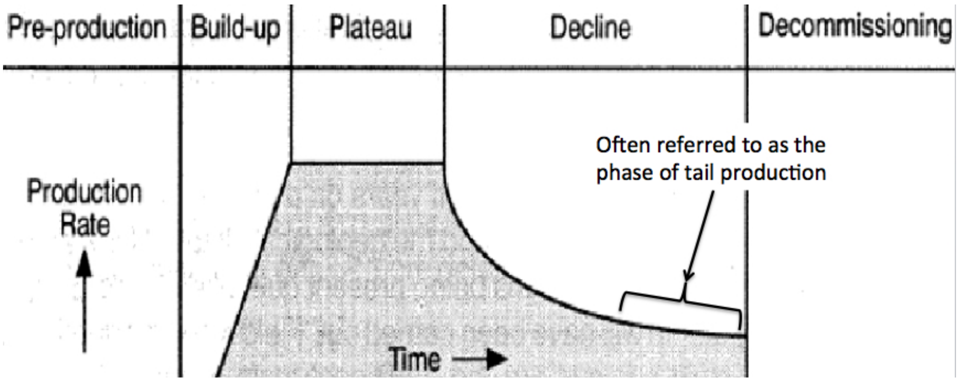


Figure 3.2: Production rate phases during field development. An increasing number of fields on the Norwegian Continental Shelf is moving into a period of declining production (Golan, 2011).

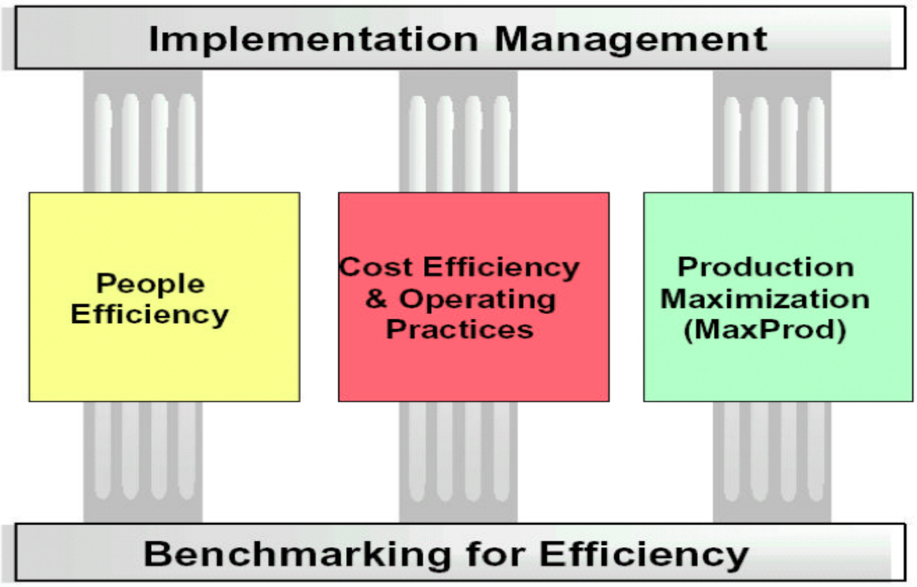


Figure 3.3: Implementation of best practices in different parts of an organization to achieve industry leading efficiency are dependent of people efficiency, operating practices and maximization of production (Ziff and Baciagalupo, 2002).

NewCo

NewCo E&P Norway AS

R-Responsible
A-Accountable
C- Consulted
I - Informed

	Well integrity engineer	Subsea Engineer	Facility Manager	Operations manager	Maintenance engineer	Pipelines inspections responsible	Finance	QHSE	Offshore technology	Well Construction and well sevice	Topside Operations
Perform QA and adapt to existing subsea strategies			A		R	R					
Evaluate and integrate operating procedures				A/R	I	I			C		
Evaluate and integrate maintenance procedures		R	A		R	R			C		
Evaluate and assess facility integrity on well				A						R	
Evaluate and assess facility integrity on pipeline				A		R					
Evaluate and assess facility integrity on subsea		A			R	R					
Evaluate and assess facility integrity on Control systems		A							R		
Evaluate and assess facility against governmental requirements			A		C	C		R	C		
Develop inspection and maintenance program subsea (well + Xmas tree)	A									R	
Develop inspection and maintenance program on subsea structure			A		R	R					
Develop inspection and maintenance program on pipeline and umbilical's			A		R	R					
Alignment with subsea inspection and maintenance			A		R	R					

Figure 3.4: RACI charts are useful to document how an activity is performed. Roles and responsibilities for each activity is mapped and thoroughly documented (Evensen and Rasmussen, 2011[2]).

R = *Responsible* *(works issues, makes decisions)* A = *Accountable* *(Reviews decisions, ensure work is done, authority if no consensus)* C=*Consult* *(should be consulted before decision is made)* I =*Inform* *(must be informed of outcome)*	Executive Mgmt	Strategic Management	Project Manager	Interface Manager	Project Team	Project Engineer	Risk Manager & Team	Operations Manager	Sales Order Owner	Order Management Group	Quality HSE Manager	Logistics Coordinator
Post Tender Award Contract Review - Commercial	I	R	A									
Post Tender Award Quality Plan and HSE			R	C	I		C				A	
Design Review Technical requirements & equipment selection		C	R	C	A		C	I				
Information Management System (WBS), Single Well Process (SWP) and PMS		I	R		C			C	A	C		I
Order Handling			C	A				I	R	C		
Manufacturing and Equipment Qualification		I	R	R			C	I	A	C		
Systems Integration Testing		C	R	A	I		C		I		C	
Crating & Shipping		I	R	C	I		C		I		R	A
Assembly		I	R		C	A	I	R				R
Installation		I	R		C	C	R	A				
Post Job Activities	I	C	R		C	A	C					

Figure 3.5: RACI Matrix as part of a completion service provider management plan (Crumrine et al., 2005).

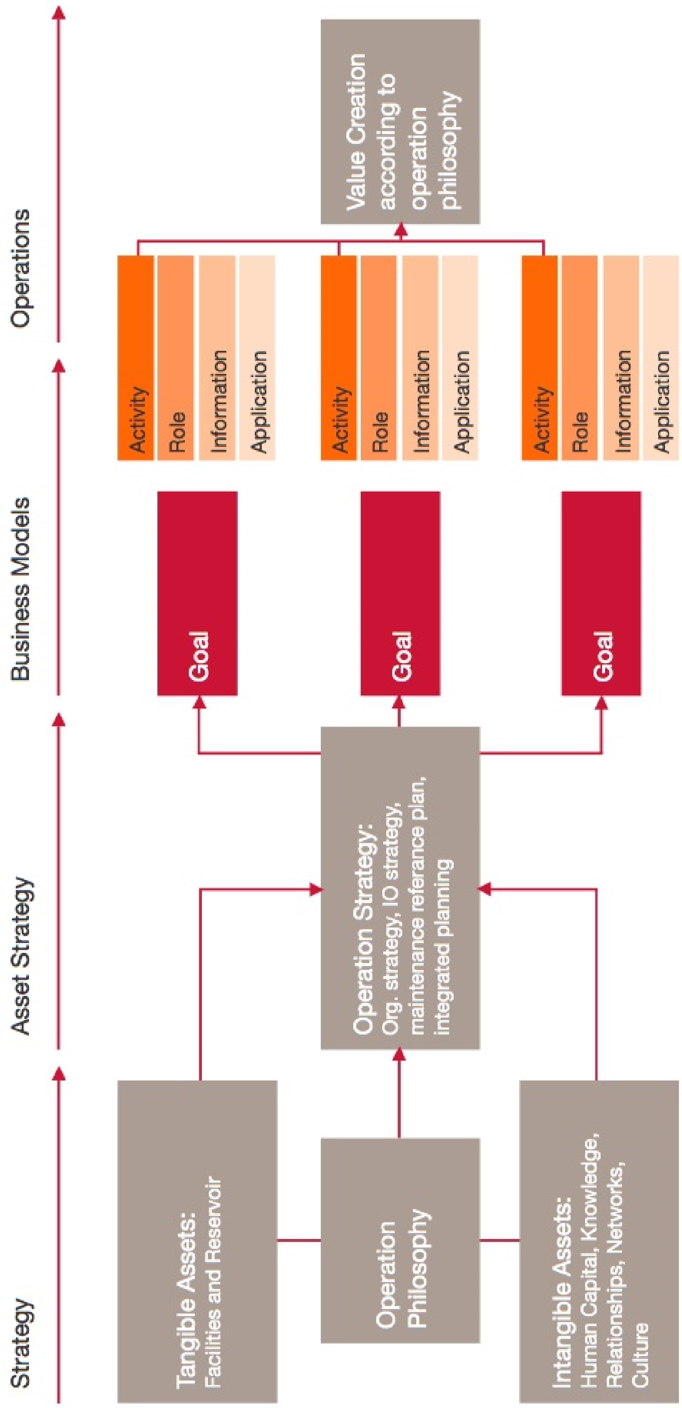


Figure 3.6: Suggested six steps to develop a taylor made business model to fit strategies and goals of company (Evensen and Rasmussen, 2011[1]).

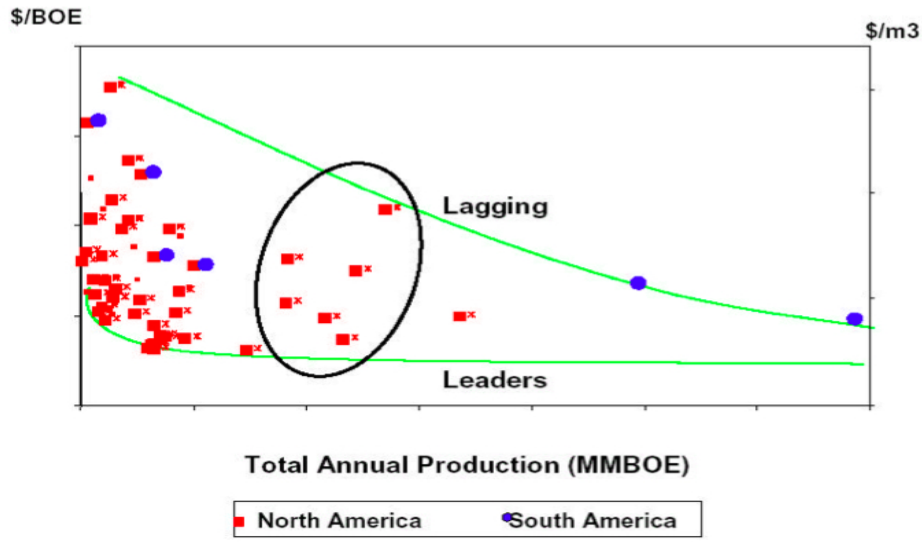


Figure 3.7: Benchmark Study: Unit operating costs (y-axis) versus total annual production (x-axis). The figure show how productivity is closely related to unit operating cost. It also reveal an area of opportunity for poor performers compared to the best ones, with a difference in operating costs of approximately $3.5 dollar per barrel of oil equivalent for medium sized fields (circled) (Ziff and Baciagalupo, 2002).

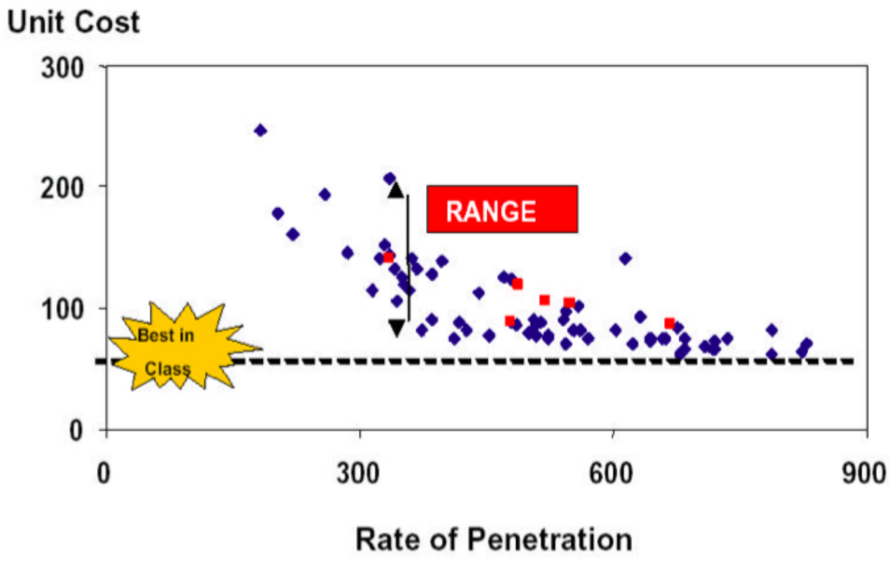


Figure 3.8: Benchmark Study: Rate of penetration (in feet per day) versus the unit cost of the well (in $ per feet) for a group of deep directional drilled well. The figure show a difference between the ones referred to as "best in class" and those with the highest unit cost. The trend seem to flatten after reaching rate of 500 RoP per day, implying that the extra unit cost per additional RoP per day is diminishing from this point (Ziff and Baciagalupo, 2002).

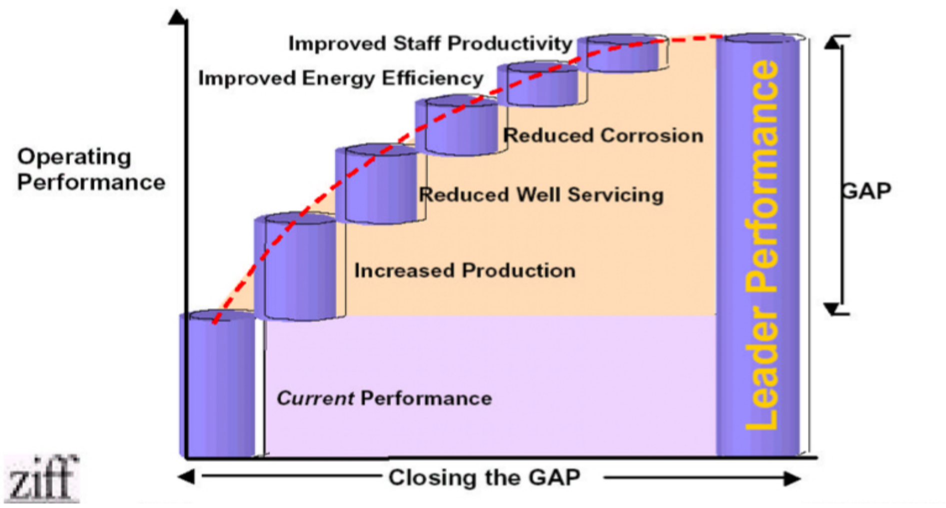


Figure 3.9: Through business mapping and benchmarking areas of opportunities can be discovered and the gap between industry leaders and poor performers reduced (Ziff and Baciagalupo, 2002).

4 Methodology

This chapter introduces the methodology used to answer the problem statement summarized in the aim of the study in the introduction. Included in this chapter is a section describing the research architecture. The chapter also include sections that elaborate on the choice of cases and methodologies used.

4.1 Research Architecture

The architecture of the research provides the framework for collecting and analyzing data. Examples of study architecture types include; cross-sectional, longitudinal design, experimental and case (Bryman and Bell, 2007). According to Yin (2009) rigid qualitative case studies allow researchers to study and explore a phenomenon using several sources of data.

A common mistake associated with the case study method is approaching a topic which is poorly defined and has too many objectives. Emphasis should therefore be put on binding the case to ensure that it remains reasonable in scope, i.e., an important part of the case study is defining the case boundaries (Baxter and Jack, 2008). This means that it is important to define the WDP and scale it to an appropriate size that favors a good analysis.

Data sources are important as they are the main source of analysis. Potential data sources used in qualitative case studies are many. These sources are seldom limited and include both archival records and physical artifacts. In case studies the opportunity to gather data from a variety of sources is significant. Yin (2009) list six sources of evidence as basis for analysis:

1. Documents

   Letters, agendas, reports.

2. Archival records

   Service records, organizational charts, budgets.

3. Interviews

   Open-ended type, focused type, structured type, survey.

4. Direct observations

   Formal, casual.

5. Participant observation

   Inside view, meetings.

6. Physical artifacts

Conclusions in case studies are based on analysis of gathered data, i.e., it is an important part of a study and should be emphasized. Yin (2009) present two general analytic strategies - one relying on theoretical propositions and one relying on developing a case description. The case description is considered the most suitable approach based on the available data and include analysis based on the general characteristics of the topic in question, i.e. the well delivery process.

Reporting case studies are often considered difficult because of the complex approach and level of difficulty related to report findings in a concise manner. It is also important to present research that will be considered trustworthy - a topic that has been given attention by various authors (Baxter and Jack, 2008) (Sandelowski, 1993)(Mays and Pope, 2000). Several elements can be integrated to increase the overall quality of the study, e.g, clearly formulation of research questions and problem statement, implementation of a suited study design, carefully analysis of data. Another element that may enhance the quality of the report is sharing of interpretation to discuss and clarify central elements. This can also contribute to additional perspectives and enhance credibility (Baxter and Jack, 2008).

Linking theory and observations is useful to enlighten observed regularities. There are two approaches to combine research and theory - deduction and induction. The deductive approach is driven by theory and the hypothesis, which comes before collecting any findings. The data is then used to evaluate the initial statement and theory. The inductive way is a reversed version of the deductive approach and gather empirical data first. Theory is then generated on the basis of this. However, there is not always a clear separation between the two approaches and they might be used in combination, i.e., changing between theory and findings. This is referred to as an iterative approach to the relationship between research and theory (Bryman and Bell, 2007). Yin (2009) on the other hand proclaims that it is erroneous to place a case study rigorously within the inductive approach, but that relevant theory suggest the direction of the research.

The qualitative case study methodology was chosen based on the contextual conditions related to the two processes being studied. The two regions investigated are also very different, i.e., context is considered highly relevant. According to the classification presented by Yin (2009), the best suited category for comparing two different well delivery processes are multiple-case studies. This enable the researcher to investigate similarities and differences within and between cases. Multiple-case studies also provides the researcher with the opportunity of comparing cases to predict results (Yin, 2009). By investigating two cases an existing uniqueness of a case is reduced, providing the opportunity to compare similarities between the cases as well as any existing differences. However, the type of study and approach was also dictated by the available data and set of resources accessible.

Theory about the well delivery process is presented initially before the two well delivery processes are presented. The well delivery process to the operator located on the NCS will act as a base case that the well delivery process to the operator in the Middle East will be compared to. These cases were deliberately selected because they offer two contrasting situations, strengthening the findings according to Yin (2009) because the conclusion arise from two independent cases.

The existing theory about the well delivery process and the two regions act as a guide to which the two processes will be compared to. This implies that a combination of the inductive and deductive research approach is an appropriate description of the research approach. The study is driven by theory to some extent, but the findings from the interviews are gathered before generating a conclusion. The aim of the study is construct theory based on empirical findings from the WDP of the OME and ONCS, i.e., to propose a strategy for how to improve the well delivery process in the Middle East and discuss future opportunities and challenges in the regions based on the data available for analysis.

4.2 Choice of Cases

When performing a case study it is necessary to choose a unit of analysis, i.e., the case that is studied. The case form can vary significantly, e.g., decisions, individuals, programs, events or processes. The case study approach provide a simple way of investigating complex subjects and is a useful tool to reveal differences in various phenomena. It is also important to decide the type of case study and the number of cases. Yin (2009) divide between several different case study categories; explanatory, exploratory, holistic, descriptive, single, holistic, and multiple case studies.

During conversations with study supervisors at PwC Stavanger and NTNU it was decided to focus on the well delivery process and investigate if there existed any regional differences. The two cases were chosen based on available information and a desire to further investigate the hypothesis of existing differences in the WDP between operating companies located in the Middle East and on the Norwegian Continental Shelf. Following the categories suggested by Yin (2009) it is most appropriate to refer to the analysis of the WDP as a qualitative case study in the multiple case study category. The need of studying and improving the WDP is based on many concerns, e.g., high costs related to drilling activities, the need of drilling more production wells in a more effective manner, being able to learn from previous operations, cost reduction through more efficient processes and the importance of transferring experience and critical information from senior personnel to the more inexperienced ones. The interest of investigating the subject from PwC Stavanger has provided the author with access to vital information that under other circumstances would have been unavailable. According to Yin (2009), access to vital information is an important element to consider when performing case selection.

By choosing the multiple case design the author is provided with divided information from individual sources. The single case design on the other hand lack this diversification effect. The multiple case study also allows for what Yin (2009) refers to as literal or theoretical replication. The literal replication imply that the hypothesis predict similar results , whilst the theoretical replication predicts contrasting results based on what is reasonable to assume. Based on the difference in location, type of operating company and expected amount of reserves the hypothesis anticipates a theoretical replication outcome.

4.3 Research Method

The research method can be described as the technique used for gathering data according to Bryman (2008). One advantage of choosing the case study type of research is the opportunity to study a wide range of behavioral and historical data sources, e.g., the previously presented six sources of evidence. It also allows for the researcher to reveal any existing similarities across data sources. Any convergence in evidence might be of importance for the analysis and makes it easier to present a reliable conclusion and represent a process of triangulation (Yin, 2009).

There are three type of forms interviews can have; structured, semi-structured and unstructured. The interviews that the analysis is based on are semi-structured and unstructured. The semi-structured form of interviewing imply that the interviewers has a list of questions and topics that guides the discussions. The reply from the interviewee can vary because he or her is given room and does not have to answer in a specific way or form. The interviews can also vary in length and number of questions (Bryman and Bell, 2007). Semi structured interviews based on an interview guide were used when collecting information about the WDP for the OME. A total of 24 interviews of personnel at the OME were conducted in the period from mid-February to mid-April (2012), each one lasting for approximately 1.5 hours.

The interviews performed to investigate the WDP of the ONCS is a combination of the aforementioned semi-structured interview form and the unstructured interview form. The unstructured interview form bear much resemblance with a regular conversation. This form of interview imply that the interviewer has a predefined set of relevant topics and questions of interest at most, but the interviewee is given much room to answer freely. A total of six unstructured interviews of personnel at the ONCS took place in the period from March to May (2012). The interview sessions lasted for approximately 2 hours in average.

The information used for analyzing the WDP have been obtained from the OME and the ONCS in similar ways. However, the type of interviews performed with employees from the OME are different from the ones performed with employees from the ONCS with regards to interview structure and numbers.

The type of documentation that the analysis is based on is versatile and include notes from interview sessions, conversations, publicly available data and internal data from the ONCS and the OME, e.g., process maps. Also important for the analysis and results are discussions and meetings with partners and senior associates employed at PwC Stavanger.

4.3.1 Analyzing Regional Challenges

The PESTEL analysis methodology is the chosen type of analysis used to elaborate on the regional challenges the operating companies are facing. The methodology is also referred to as PEST analysis and PESTEL analysis. PESTEL is an acronym that consist of Politics, Economics, Society, Technology, Environment and Legal. The form of analysis is a useful tool to categorize driving forces and is often used in market and business analysis. Driving forces are usually hard to control and the best way for companies to approach these forces is to recognize and try understanding what effect they have on their business (Schwartz, 1996). The PESTEL can be used as a tool to gain insight into external elements that might influence an operating company, the environment an operating company is present in or critical elements important for an operating company, e.g., the oil price.

Political factors can refer to government policy and the degree of intervention in the economy. What are in the interest of the government and how does it affect the operating company is example factors that might have an effect. Economic factors include interest rates, taxes, economic growth. Changes in trends that can affect the demand for oil and availability of qualifies personnel are Social factors of importance, as it can influence cost for firms. Social factors are for example changes in social trends that have an impact on the company. Technological factors are related to development of new products that have an effect on the E&P industry Development in technology can lead to reduced costs and new ways of performing operations. Examples of areas in the E&P industry that can benefit from development of new technology are many and include extended reach drilling (ERD), methods for increasing reservoir drainage and subsea production systems. Environmental factors include weather and environmental change. Major climate changes is an example of something that can have an effect on industries as a result of the consumer becoming more environmental aware and the general society becoming more environmentally. Legal factors are are linked to the legal surroundings that the operating company operate in. Recent years many companies have been affected by legal changes, e.g., significant legal change in the UK though the increase in minimum wage and greater requirements for firms to recycle (Gillespie, 20111).

Using the PESTEL type of analysis it is more easy to analyze the different factors that affect the ONCS and the OME. The importance of the factors may vary between companies. A firm that have borrowed significant amounts of money has to emphasize economic factors (E), while a company within the medical industry has to pay more attention to technological development (T) of medical equipment and legal factors (L) affecting the availability and use of different types of medicine. It is important that companies consider which factors are most likely to have the greatest impact on them. The importance of a factor is dependent on the likelihood of the factor to change and the possible impact.

5 The Well Delivery Process

The Well Delivery Process defines the set of activities in place to plan, execute and deliver a well (de Wardt, 2010). The process is of paramount importance as it secure presence of key elements, e.g., participation of key employees, probabilistic time scheduling, cost estimates and technical solutions. The difference between a well functioning and poorly functioning well delivery process can be severe. A poorly process will lack the ability to implement improvements and fail to capture key elements. The discrepancy between a high and low quality well delivery process can be significant both in terms of HSE, finance and utilization of resources within an operating company.

The well delivery process (WDP) is extremely detailed and include a significant number of different elements. The complexity of the WDP is exemplified by the stage influence diagram of the well concept selection depicted in Figure 5.1, which is one of several sub-processes of the WDP.

Multiple Definitions

The WDP is defined in different ways. one example is described by de Wardt (2010). The process start off at a concept stage and end in close out and handover of the well to production.

Another Well Delivery Process definition initiate the process at a business case preparation sequence in stage 1 and end in a management reporting sequence at stage 12. According to this approach, each of these twelve processes will have numerous of own sub-levels.

A third definition of a WDP was described by Okstad (2006). This WDP is triggered by owners and stakeholders in the company deciding to develop a field, where the first step is the identification stage that consist of reviewing reference documentation and the basis for the well design, in addition to a preliminary analysis of alternatives. The process is ended the a design option that is within the limits of the basic concept is selected and the integrity of its barriers is verified.

A fourth definition is the one used in this study, i.e., the set of key activities performed by the drilling department from receiving the request to drill from the field development team until the well is closed out and handed over to production (Figure 1.1).

Figure 5.2 depicts many definitions of the WDP and how they can overlap and have different names that describe similar processes.

Aim of the Well Delivery Process

The well delivery process (WDP) aim to secure a satisfying level of accuracy in the preparation phase so that the level of risk and uncertainty in the operating phase is minimized. The process require interdisciplinary cooperation between departments in an oil company and suppliers.

Depending on the type of well the process utilize different techniques and methods to create and define the aforementioned activities. Exploration wells in an unknown area require a more detailed and longer well delivery process, whilst a shorter and more pre-defined plan can be used when drilling development wells in known environments.

5.1 Well Delivery Process Tools

There are currently numbers of tools available to assure the quality of a WDP. Most of these tools were presented by de Wardt in 2010. Even though there are several different types of wells, the tools presented in the following are applicable to most operations even though their degree of necessity differ. Tools described in this section are:

- Stage gates
- RACI charts
- Pre-spud sessions
- Technical limit processes
- After action reviews (AAR)
- On paper exercises
- Peer reviews

A more complete list of WDP tools available are presented in Table 5.1. WDP tools in Table 5.1 not explained in this section are placed in Appendix F.

Stage Gates

A stage gate can be defined as a holding point that need manager approval for the project to proceed. Stage gates, also referred to as decision points, break a project into stages so that each process is easy to identify. They provide organizations and departments with the opportunity to develop, plan and supervise operations within a pre-defined framework. Stage gate processes also assure that project phases are revised before it is decided if they can proceed forward to the next stage. Each stage contains detailed information regarding work and accepted range of uncertainty. They also have defined deliverables and secure that important competence is included in the process. Requirements at decision points is therefore detailed and contain specification on type of approval and authority to give approval. However, it is important to emphasize that decisions can be made at gate points without undertaking more work than necessary. If good reasons to proceed to the next stage exist, stage gates can be partially avoided. In such a case it is important to document why the exception was made together with requirements for delayed approval to be accepted. Similar documentation should be provided in case of an accelerated decision processes for long term commitments.

Stage gate process also secure proper pre-project planning in the WDP. Studies conclude that pre-project planning, or front end loading, have the possibility of increasing the value of a process and offers an opportunity to lower project costs (Batavia, 2001)(Popham, 2010). It is however important to emphasize that front end loading can lead increased cost of projects, especially if it is commenced before the economic value of a project has been validated. On the other hand, poor pre-project planning can lead to an insufficient amount of resources being tied into the project - potentially leading to bad decisions being made and suboptimal well concepts being initiated. The importance of a well distributed amount of work in front end loading a project should therefore be considered in a WDP. This increase the likeliness of completing an optimal amount of work before stage gates.

Figure 5.3 illustrates how key parameters in the WDP develops as the process proceeds. The financial commitment to the project increases with time and is negatively correlated with its uncertainty. Simultaneous activities in between stage gates aim to reduce uncertainties of a project by gathering and processing important information.

An early discovery of poor business opportunities are important in order to allocate resources as effectively and efficient as possible. It is also important that complications in a project are detected early so changes can be made and further complications avoided. A well functioning system have the ability to filter out and avoid undesirable projects. It also has the ability to detect projects that are in need of re-engineering to avoid further problems.

Well defined stage gates implement points where the well project is revised and quality checked. This will increase the chance of the correct wells being forwarded as good business opportunities that are properly planned. The decision gates normally contain a predescribed list of deliverables. The list is revised and projects have to meet clearly defined expectations in order to be approved. It is also common that stage gates require a plan on how to proceed further in order for the project to be approved. It is also common that wells are given a score at stage gates in order to prioritize and rank projects. The score is given based on objective and pre-defined criteria. Resources are committed to wells approved through a stage gate.

RACI Charts and Pre-Spud Sessions

RACI charts are also referred to as RACI matrices. RACI chart is a tool used to clarify roles and responsibilities assigned to a project, process or activity. The tool is further explained in section 3.1. The standard chart lists tasks or deliverables in the left column, which is often vertical. Roles are stated across the top row along a horizontal axis. For each role the letters are inserted to show who the distribution of responsibilities. The tool is very effective when new teams are being formed and when the WDP is implemented. However, charts that are too big and complicated are often overlooked by employees.

Pre-spuds are a term for sessions that include rig and service company crew to share and elaborate on the drilling process and the planning behind it. The goal is to hand over the program to the executing team so that the team feel process ownership and is provided with the necessary information to perform the operation successfully. These sessions are scalable, i.e., a high risk wells often require a full scale offsite pre-spud including many crew members and being rich in detail. For repetitive process wells, e.g., during batch drilling, small onsite pre-spuds are often sufficient to implement lessons learned and present relevant challenges.

Technical Limit Processes and After Action Reviews

Technical limit process is a way of working with planning teams to identify areas of performance improvements. Improvements in design, operations and technology are revised by aiming on a goal that is significantly better than current performance. An example of such a process was applied by Bon et al. in 1996. The authors asked planning teams and operations personnel what would be possible if every operation that made up well time went perfectly. The authors also introduced the concept of invisible lost time, which is defined as the unrealized gains possible through improvement. The technical limit process aim to create plans to reduce the non productive time and invisible productive time to achieve the largest gains that are possible. An alternative method is the use of performance stretch goals in the planning process, i.e., incorporating a goal that is considered possible to achieve even though the ways of achieving it are unknown. The goal is to cause a creative atmosphere within the team that focus on a high performance outcome. This can lead to significant improvements when implemented early in the planning phase as it enables major changes in practices and application of new technology. The technical limit process should first and foremost be applied to review drilling and completion time.

An important element of the final part of the WDP is to learn from what has been experienced and incorporating this into future planning of procedures and operations. This is important to focus on continuos learning for the operator to be able to perform at its best. The After Action Review (AAR) is a process defined for this purpose and can be carried out at any time during an operation. The optimal way to capture lessons learned is after a clearly defined part of the operation, e.g., after completing a hole section is finished. The AAR aim to discover elements that did not go according to schedule, analyze the cause of deviation and incorporate it as a learning element for future operations. It is suggested that a log containing lessons learned is made. The log should contain details about lessons and include information on what is done to follow them up. It is also of benefit if the log is categorized and made easy to use. The AAR should be led by an employee or a third party that is familiar with it and all personnel who were involved in the operation must participate in the process. The facilitator should try to create a friendly and non-blame atmosphere required to assure that as much relevant information as possible is revealed, shared and used for learning.

On Paper Exercises and Peer Reviews

Workshop exercises of drilling and completing well on paper are useful to review detailed drilling plans by the team responsible for executing the process. The exercises are often referred to as Drilling the Well on Paper (DWOP) and Completing the Well on Paper (CWOP). The purpose is to challenge the integrity of the plan to assure that critical details are not omitted. It is also useful to verify the timing of the operation reveal any unnecessary elements that can be removed or improved to make the operation more effective. Critical time can often be reduced by performing activities in parallel, e.g., using pre made BHA's and applying completion sections that have been gas tested and length adjusted to match existing rig equipment. Dual derrick drilling system is an example of a tool that is well suited to perform parallel activities. The system is well suited to make up connections prior of any critical well procedure and can reduce time by running the christmas tree[1] (XMT) at the same time as pulling out of the hole (POOH). A horizontal christmas tree is depicted in Figure 5.4. By conducting on paper exercises critical and unusual procedures are repeated to avoid errors and the operator have a way of assuring that roles of various companies, employees and processes are fully understood. Key elements included high quality exercises include oped, including and discussion friendly.

Peer reviews or peer assists is a method to review the planning work of wells with subject matter experts. Peer review sessions are often performed several times and aim to assure that the plans and programs are robust and of high quality. Sessions are of particular necessity for high risk projects and are often mandatory for passing stage gates. They are not required when doing repetitive wells, but can be implemented in the planning phase if results are not as expected to bring insight and useful input that can improve the quality of the process. Peer assists is a meeting where outside experts are invited to share their experience and knowledge with the team in need of assistance. Peer assist sessions are most often initiated when a team is facing a challenge.

[1]A christmas tree is an assembly of valves, spools, pressure gauges and chokes fitted to the wellhead of a completed well to control production

5.2 Lessons Learned

Previous experience by de Wardt (2010) have shown that operators often miss opportunities for improving the WDP. These opportunities can be significant as they in some cases have the potential of resulting in benchmark performance.

Insufficient Scaling of Useful Tools

Experience has shown that once companies who have developed and implemented a WDP start to get familiar with the process they often skip tools in the belief that they no longer bring value to the process and that they can save time and effort in the planning phase. However, the consequences are often poor results in the execution phase. It is suggested that rather than eliminating tools they should be scaled to fit the situation. It is also important that tools are used in a correctly manner and that the quality and degree of application of tools are verified.

A West African operating company was able to directly correlate differences in drilling performance in wells with and without the use of risk management. Another example also related to use of risk management is how an operator proclaimed that they were using it correctly. Further investigation showed previous system stagnation without any proper change plan and several cases of poor logic in the ranking system because it was copied from a previous process. This resulted in risks occurring during the process execution as they had not been properly ranked. In addition, means of mitigation were not present.

Management support and commitment is important for successfully implementing elements to improve the WDP. An example is how management support is considered important when developing an audit process along with the WDP and when implementing new technology in the planning process. Management commitment is required for achieving an effective WDP because it requires investment in the planning process of a well. Lack of commitment can result in failing to implement the WDP because it does not exist a focus on front end loading the planning process.

De Wardt (2010) state that it is common to focus on reducing the cycle time of a WDP to increase the NPV of development projects. Reduction of cycle time can come from adapting parallel engineering and incorporate means to make the WDP more effective. However, some companies simply reduce their time for planning and believe that this alone will reduce the cycle time. It is important to take into account that this can lead to poorer execution, delays, extra costs and poorer functionality. Another experience is how some companies have acquired drilling rigs without adding capacity in the sub surface department. This can result in drilling consuming all available prospects, leading to reduced performance because of inadequate completions. Operators should focus on balancing the departments so that subsurface information can be incorporated in the WDP early enough for the operator to set a correct and accurate planning time.

Operators that have implemented a WDP often fail to implement an effective audit and correction process to revise the process. The consequence is a decreased level of robustness and the WDP failing to deliver the desired results. It is important that the management in an organization understand that it is important to correctly implement the WDP and that it is vital for the success of the WDP that the application of it is maintained.

5.3 Characteristics of a Successful WDP

Certain elements that characterized successful well delivery processes was presented by de Wardt (2010). Characteristics of a successful WDP include:

- A clearly defined well delivery process that is taylor made to fit the operating company and its application is important.

- It is also found that leadership is an important driver behind the implementation of the WDP. Drive and discipline of leaders and a willingness to use the system, its stage gates and adapt to lessons learned is crucial.

- A successful WDP frequently use correctly selected process tools. It can also be scaled to fit the type of well, i.e., a significant amount of effort should be applied to projects that have significant risk and uncertainty tied to it, while it is sufficient to maintain the quality of the process for repetitive type of wells, e.g., batch drilling.

- Implementation of the WDP should be agreed on and rigorously followed with a minimum need of management intervention. This means that the team understands the importance of the WDP.

- Another important element is to accept that no processes are perfect and realize the benefits from implementing lessons learned. They should be applied into the WDP to make it relevant and updated.

- It is also recommended to use KPI's to monitor the process and make it more easy to detect changes.

- Another element considered important to achieve a high quality WDP is to measure performance against internal goals and industry benchmark. This enable the operator to monitor the WDP and make corrective actions if needed.

Well Delivery Process Tools
• Stage Gates (equivalent to decision gates).
• RACI charts.
• Pre-spud sessions.
• Technical limit processes.
• After action reviews (AAR).
• On paper exercises - drill well on paper (DWOP) or complete well on paper (CWOP).
Useful process tools described in Appendix F include:
• Peer reviews.
• Basis of Design (BOD).
• Risk and uncertainty management.
• Detailed scheduling.
• Master equipment list (MEL).
• Probabilistic cost estimating.
• Learning lessons.
• Guidelines, procedures and check lists.

Table 5.1: Process Tools used to enhance the quality of the WDP (de Wardt, 2010).

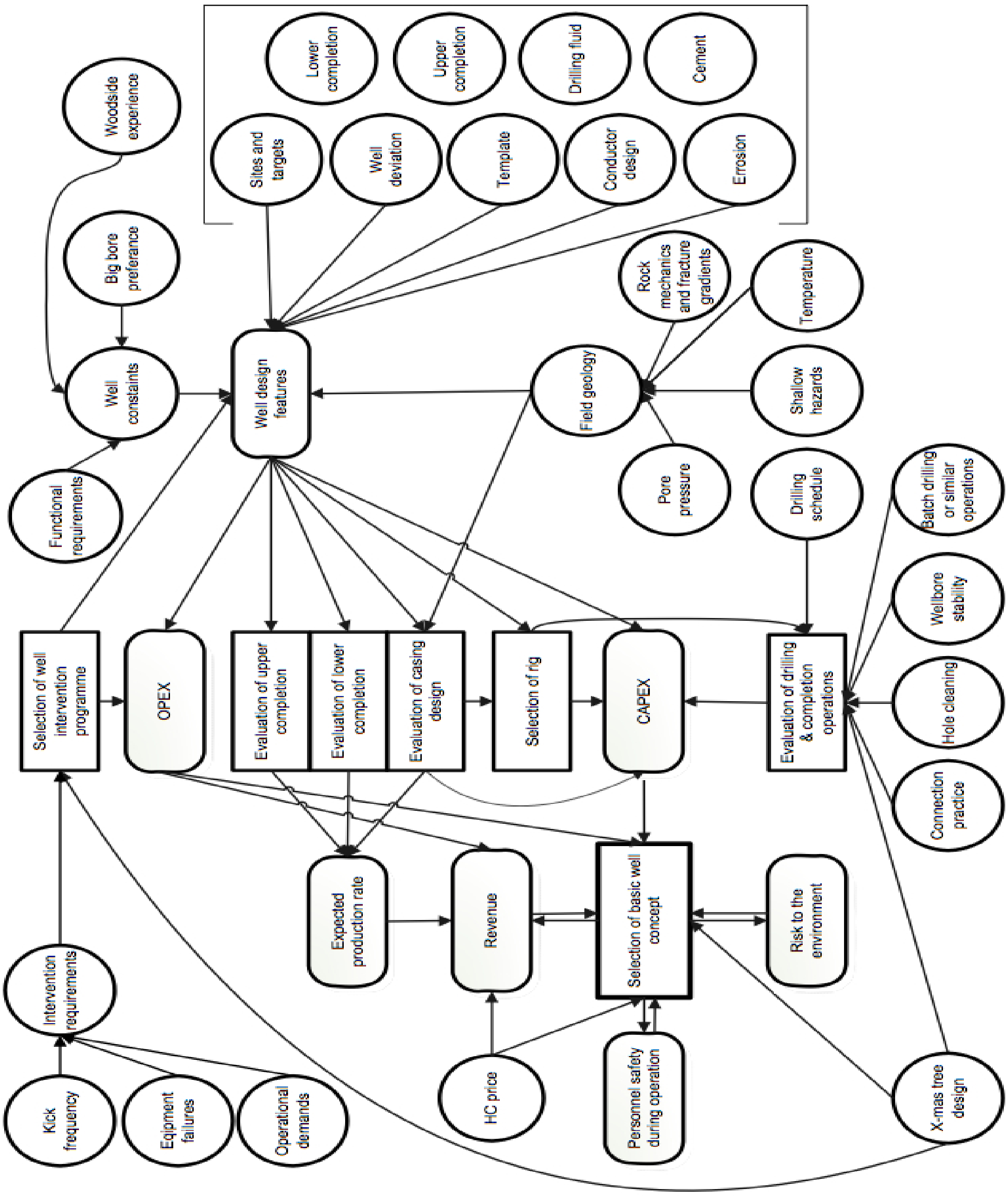


Figure 5.1: A detailed stage influence diagram of well concept selection exemplifying the complexity of the WDP as a whole (Okstad, 2006)

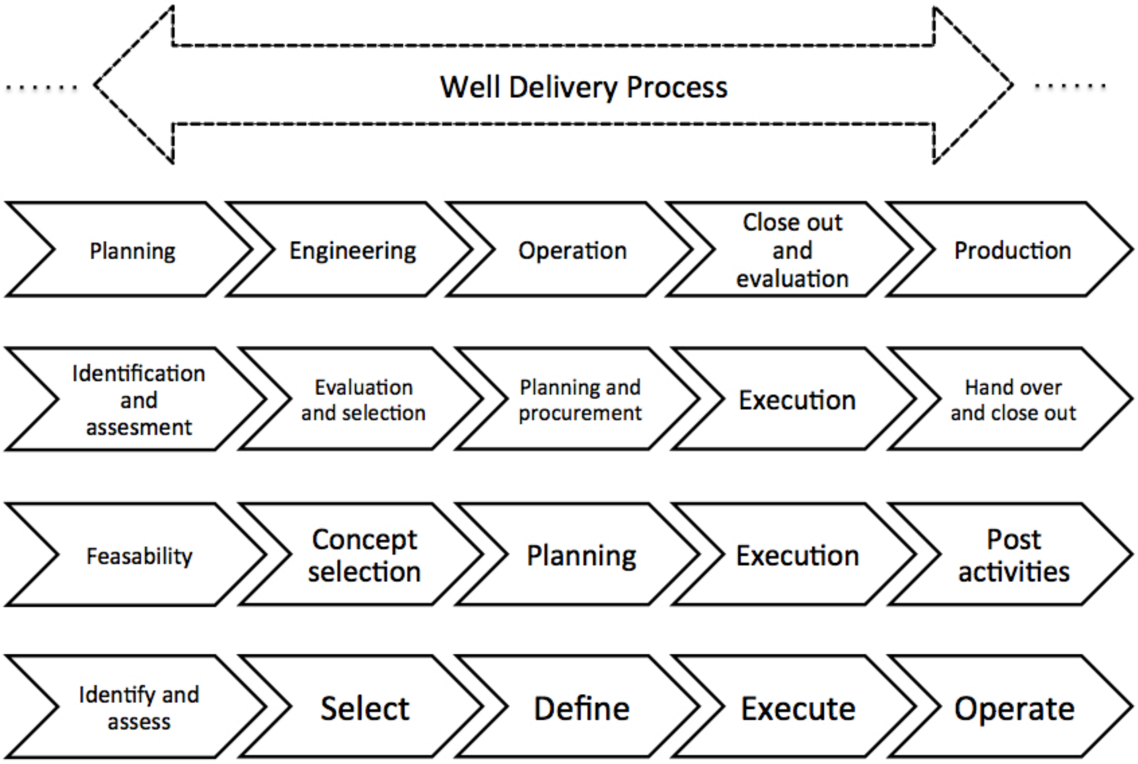


Figure 5.2: Many WDP definitions can overlap and have different names describing similar processes.

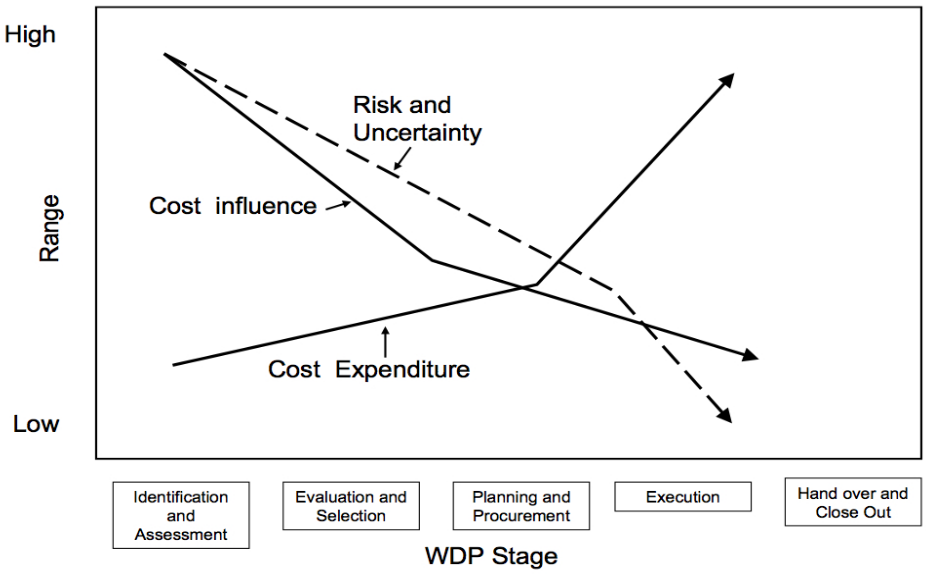


Figure 5.3: Risk and uncertainty as well as cost influence decreases as the WDP proceeds. Expenditures increase (de Wardt, 2010).

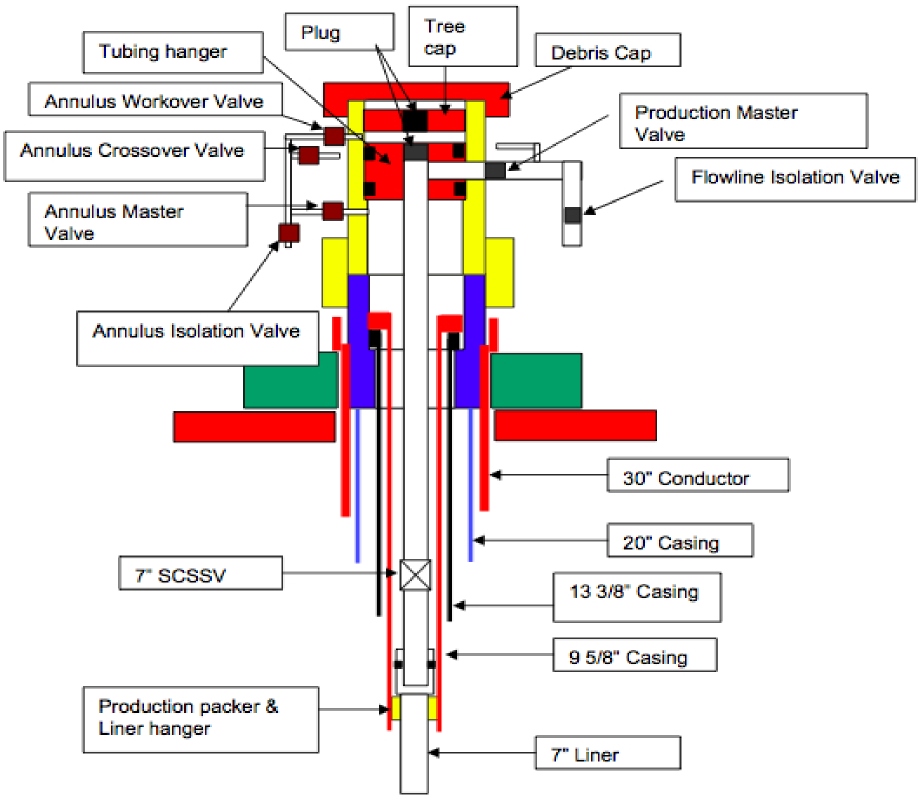


Figure 5.4: Horizontal christmas tree where the tubing hanger and the tubing is suspended in the tree (Sangesland, 2011).

6 Case Presentation

It is important to highlight central elements of the study assure that the reader can assess its validity and credibility (Baxter and Jack, 2008).

This chapter gives the reader a brief introduction to the two energy regions and the two operating companies investigated in the study. The purpose is to contextualize the status of the oil and gas industry in the region and give the reader an impression of the two operating companies. Also mentioned are regional reserve replacement rates and other elements to which the operating companies have to adapt and consider. The chapter also provide information that support analysis of future challenges and opportunities the two companies face in the years to come.

6.1 Introducing Energy Regions

6.1.1 The Norwegian Continental Shelf

Key Figures and Reserves

The petroleum sector in Norway is the biggest industry in the country measured by value creation, government revenues and export value, contributing with approximately 20% of the value creation in the country and 25% of the revenue. The value creation by the industry since its start has been significant and was estimated to a total of 9 000 billon NOK in 2011 money (Norwegian Petroleum Directorate, 2011).

Norway is number seven of the list of biggest oil exporters, following the United Arab Emirates in sixth place with a total export of 97 million tonnes in 2009 (International Energy Agency, 2011). The total amount of recoverable reserves on the NCS is estimated to be approximately 81.8 billon barrels - 0.11% of the estimated resource volume in the Middle East (Norwegian Petroleum Directorate, 2011).

The U.S. EIA (2012) state that the amount of proven reserves in Norway is approximately 5.67 billion barrels of oil as of January 1., 2011. The discrepancy in numbers is a result of different dates of reserve registration and different terms with regards to reserve classification, i.e., requirements for reserves being placed in the "recoverable reserves"-category by the Norwegian Petroleum Directorate are different from the requirements for reserves being placed in the "proven reserves"-category by the U.S. EIA.

Equitable Depletion Index and Reserve Replacement Ratio

It is difficult to compare the NCS to the Middle East with regards to total amount of resources and production rates. However, a paper by Omowumi et al. (2007) looking at the global petroleum upstream industry enable comparison between the Europe and Eurasia region and the Middle East by looking at the equitable depletion index (EDI) and the reserve replacement ratio (RRR) in the two regions. The equitable depletion index is a measure of the degree of long term reserves and production rate compared to other producing areas of the world. It is defined as the ratio of the share of crude oil global production to the share of global proved oil reserves in a given economic, geopolitical or geographic region worldwide.

A good strategy would be to keep the share of global production proportional to the share of global reserves. This would provide market stability in the long run, i.e., a ratio bigger than one would indicate an unreasonable production of reserves. If the EDI is one the production is reasonable to their share of reserves. The NCS is part of the Europe and Eurasia region, which as of 2006 had an EDI of 1.847. This means that a lot more is produced in the region compared to its share of proved oil reserves (Figure 6.2).

Looking at the the reserves replacement ratio for the same region a similar tendency is revealed. The index measures the proved reserves added to the reserve base relative to the amount of oil and gas produced. The aggregate RRR from 1980 to 2006 the RRR for Europe and Eurasia was at 92.6%.

A closer look at the NCS can be provided by looking at the quarterly reports of the biggest operator on the NCS - Statoil. According to their fourth quarter results of 2011 the three year average RRR for the company was at 92% - approximately the same as the RRR for Europe and Eurasia from 1980 to 2006.

However, it is reasonable to assume that the average RRR on the NCS is somewhat lower than this. This is because the results presented in the report include Statoil's international RRR and takes into account the effects of sales and purchases. Another reason to expect that the average RRR on the NCS is lower than 90% is the positive RRR effects of 2011 of 117%, which was a good year for the NCS. The three year average RRR for Statoil in 2010 was 64% (Statoil, 2012).

Managing Resource Wealth

A challenge for many regions with significant accumulation of hydrocarbon is finding a proper way of managing the wealth associated with the resource. The oil curse has become a well known phenomena. The phenomena refer to how countries with significant amounts of petroleum resources often experience a lack of democracy, economic instability and an elevated likelihood of civil war (Ross, 2012). That is why the Norwegian way of developing itself as an energy region is regarded as a prototype to copy by many producing countries in the third world.

Key aspects of the Norwegian way of developing an energy region include the state as owner of the resources, as well as being the legislating institution, the licensor and regulator. The government also has a direct involvement commercially through ownership in Statoil and the aforementioned Petoro, which manage the state s direct holdings in the sector. The approach of a solid government control is executed through a structure consisting of three components; The Ministry of Petroleum and Energy, responsible for the licensing policy, The Norwegian Petroleum Directorate and the Petroleum Safety

Authority Norway, in addition to the commercial component of ownership in Statoil and Petoro.

In addition to these three components, clear principles were established from the beginning to guide the new and growing petroleum industry. These principles are known as the ten oil commandments laid by the Norwegian Storting. These commandments are listed in Table 6.2 and yielded important conclusions, which still applies. The oil and gas resources on the NCS belong to the people and must benefit society. The oil and gas industry must be managed so that it is an era and not an episode. Thirdly, when transferring petroleum resources into financial assets, the aim must be to achieve a qualitatively better society (Lerøen, 2010, 2012).

Taxes and the State's Direct Financial Interest (SDFI) on the NCS are two examples of how the petroleum sector creates income for the Norwegian government. The SDFI manage production licences, fields, pipelines and land-based plants as the on behalf of the Norwegian government through the oil company Petoro. Apart from Statoil, Petoro is biggest owner on the NCS. In 2011 the net cash flow from SDFI on the NCS was NOK 128.1 billion (Petoro, 2012). The volume of oil produced on the Norwegian Continental Shelf (NCS) has experienced a declined of approximately 4% since 2007 and the Norwegian Petroleum Directorate (2012) expect the decline in oil production to continue (Figure 2.12).

Simultaneously, the Norwegian central bank has advised the government to spend less of the Norwegian sovereign-wealth fund, also referred to as the Norwegian Government pension fund - global. The fund manage and control the income from the petroleum sector. The government initially set a spending limit of 4% to avoid over spending, but in February 2012 the central bank Governor Øystein Olsen suggested to lower the spending limit by 1%, proclaiming that the current amount of spending is too high and that funds real return is expected to be lower than 4% in the future years (Kremer, 2012).

The combination of a declining production of hydrocarbons on the NCS and too much spending of money generated by the petroleum sector is unfortunate.

Regions and Geology

The Norwegian Continental Shelf is divided into three parts - the North Sea, the Norwegian Sea and the Barents Sea (Figure 6.4). The souther part of the North Sea include Ekofisk, which is the largest field on the NCS. The field also serve as a hub in this area, with several other fields utilizing its infrastructure. The reservoirs in largest fields are mainly chalk and the area is expected to produce for approximately another 40 years. The central part of the North Sea currently consist of 19 fields, with 3 fields being developed.The Northern part of the North Sea consist of two areas (Oseberg/roll area and the Tampen area) and consist of 26 fields in production. It is assumed that the region continues production for approximately 30 years. The area contains the Troll field, which is a major contributor to the gas production from the NCS. The Norwegian Sea and the Barents Sea is less mature petroleum provinces and consist of 14 fields in total. Snhvit is the only field developed in the Barents Sea, but the discovery of Havis and Skrugard in 2011 will increase the number of fields in the Barents Sea along with the Goliat field, which is expected to start production in 2013. There are several operating companies present at the NCS, e.g, ConocoPhillips, Shell, ENI, Total, Wintershall. The largest company on the NCS is Statoil, controlling approximately 80% of the oil and gas production in Norway.

Reservoirs on the Norwegian Continental Shell mostly consist of large deltas formed by rivers that ran into the sea during the Jurassic Age. The reservoir of major fields on the NCS, e.g., Gulfaks, Oseberg and Statfjord, are in the Brent delta from the Jurassic Age. However, other depositional environments are also present. The Snorre field is deposited on alluvial plains from the Triassic Age, the Troll field is present in shallow seas from the Late Jurassic Age and the Balder field are found in subsea fans from the Paleogene Age. In the southern part of the North Sea large layers of chalk consisting of microscopic calcareous alga are the dominant reservoir rock(Norwegian Petroleum Directorate, 2011).

The NCS has a total of 522 fixed installations, with 157 of these being above the surface. All oil and gas discoveries made on the Norwegian Continental Shelf are off-shore (Norwegian Ministry of Petroleum and Energy, 2011).

6.1.2 The Middle East

Countries and Reserves

The geographical coverage of the Middle East include a total of twelve countries. These countries are listed in Table 6.1(International Energy Agency, 2011). The region has by far the biggest proven oil reserves in the world. As of January 1, 2011 the region had an estimated volume of 753 billion barrels of oil (Figure 6.1)(U.S. Energy Information Administration, 2011). Looking at the dominant oil producing countries of the Middle East it is evident that Saudi Arabia is the biggest. The kingdom is followed by Iran, the United Arab Emirates, Kuwait and Venezuela .

The Middle East has a promising future with regards to petroleum resource development as they historically has replaced produced reserves with more than 400 percent from 1980 to 2006. The Middle East has a low EDI with a index level of 50%, meaning that their share of global oil production was half their share of global probed oil reserves. When regions produce in excess of their share of world reserves they risk transferring market power to regions with low EDI ratios. This imply a further shift in market power to the Middle East in the future. Equitable Depletion Index for crude oil reserves for major regions from 2006 is depicted in Figure 6.2 (Omowumi, 2007).

Looking at RRR for the Middle East in Figure 6.3 the strong position of the region with regards to available resource development is confirmed. The RRR in the Middle East is a factor of 4.41 bigger than the RRR in Europe and Eurasia and and a factor of 2.01 higher than the region with the second highest RRR, which is South and Central America.

An interesting result of recent commercialization of enormous amounts of shale gas resources in North America is how the oil and gas industry can look towards the Middle

East to investigate a potential presence of significant amounts of shale gas (Bouhlel and Bryant, 2012).

Oil and gas discoveries in the Middle East are located both on- and offshore.

Role of Fossil Fuels

Looking at the regional demand in the Middle East it is evident that it rely on oil and natural gas to meet their energy demand. Demand for gas is expected grow and become more important in the future as efforts to displace oil consumption with gas to provide a sustainable oil export in the future are implemented. The energy demand in the Middle East is driven by industry and power generation as the industrial sector is in need of petrochemicals and the energy intensive LNG production is expanding.

The oil displacement and improvement in efficiency in the Middle East is based on growth in regional gas supply. However, it is reasonable to believe that failing to achieve this growth will lead to oil filling the discrepancy between supply and demand (BP, 2012).

The Middle East has experienced a rapid growth in income per capita since 1970 . Naturally, the energy intensity of the region has grew as a result. The intensity grew from half the level of other non-OECD countries in 1970 to 50% higher by 2010. Due to indications of reduced energy intensity in other countries it is expected that the Middle East region is likely to be twice as energy intensive as other non-OECD countries by 2030. The intensity of the Middle Eastern region is most likely linked to its comparative advantage of having easily accessible energy available.

Contrarily to what is procedures in Norway, many Middle Eastern countries have subsidized oil products and natural gas. This has contributed to the current oil intensity. However, indications that governments are willing to implement measures that can reduce intensity are present. Iraq has reduced oil subsidies as a result of an agreement with the International Money Fund (IMF). Iran has substantially increased the domestic price of fuels due to international sanctions and Saudi Arabia committed to end fossil fuel subsidies in 2010. Oil is the biggest part of the energy production in the Middle East. The current percentage is 75%, but it is expected that it will be reduced to 67% by 2030 as a result of the expanding gas production. However, even though the percentage is expected to decrease the total oil supply is believed to increase by 10 million barrels per day. The gas production is expected to increase by 41 billion cubic feet per day (BP, 2012).

Workforce

It is of interest for nations in the Middle East to have their most important natural resource managed and developed by local workers. Therefore there is currently a need of nationalizing work force in Middle Eastern oil companies. This was emphasized by Aggour (2005) that stated that oil companies need to provide educational programs to produce qualified engineers that originates from the Middle East. The same author emphasize the unique structure of many national oil companies in the Middle East that may differ from other companies in the world. Many of the region's national oil companies are involved in the nationalization campaign of their country. The aim is decrease their dependency on foreign labour and expertise and employ more local workers throughout various industry. Most of the major oil producers in the Middle east established their industries with help from foreign expertise from foreign companies. When national oil companies were built the trend continued, i.e., the majority of employees in the Middle Eastern region are expatriates (Aggour, 2005).

Geology

Most of the reservoirs in the region are simple stacked systems of multiple carbonate platforms and deltaic clastic reservoirs. The source rocks present in the region is considered world class and the presence of large compressional anticlines in fold belts and foreland settings is considered very favorable (Fraser, 2010). The presence of carbonates imply large heterogeneties in reservoirs with varying permeability, presence of large cavities and porosity, with oil being produced through fractures in the reservoir. However, large areas of homogeneity can also be observed. Problems with drilling in carbonate reservoirs are often related to mud loss and lost circulation as a result of fractures and heterogeneties (Mohd, 1996).

The oil in the surrounding of the Arabian/Persian Gulf is located in Mesozoic and Tertiary reservoirs. The source rock is mainly from Jurassic and Cretaceous argillaceous and carbonate rocks. The Cretaceous petroleum reservoirs of the Middle East are divided into two main tectonic provinces; the Arabian Platform and the Zagros Fold Belt. The Arabian Platform is known by an inverse correlation between average porosity and burial debt in carbonates and sandstone present. The Zagros Fold Belt mainly consisting of carbonates has no distinctly porosity and no depth correlation. The oil in the region matured, migrated and accumulated during late cretaceous times and onwards, but at different times in different parts of the region. The oil is today present because of restricted intrashelf basins and depressions (Ehrenberg et al., 2008)(Stoneley, 1987).

6.2 The Operating Company in the Middle East

The information in this section is based on independent statistics and country analysis from the U.S. Energy Information Administration (2012) and publicly available information published by the operating company in the Middle East

History

The Operating Company in the Middle East (OME) was established in the beginning of the 20^{th} century. The company was originally formed through a cooperation between several of the seven sisters[1]. After approximately 50 years the Government took the control of the nations resources and acquired the remaining part of the operating company after discussions the other partners. After having planned how to proceed to achieve a fully integrated and nationalized oil industry, several important actors operating in the petroleum sector were acquired and nationalized in the years to come. Approximately five years after that the nation formed a head company with the purpose of gathering all of the existing oil companies to form one integrated oil industry. The OME is now an upstream subsidiary of this company.

Activities

The company has activities in several parts of the upstream value chain. It is involved offshore and onshore surveying, field development, drilling activities and exploration activities and operations. The accumulations of hydrocarbons mostly consisted of oil until the country found gas located in deep Jurassic reservoirs some years after the new millennium. The company believe that this will result in the country being self-sufficient in gas, which will be used for generating power to make the country less sufficient of others. However, many discoveries of natural gas are located in geologically complex reservoirs and consisting of sour gas. This makes the extraction process difficult and costly.

The constitution of the nation prohibits any international oil company from having equity stakes in development projects. To solve technical challenging tasks the OME therefore use technical service agreements to cooperate with international oil companies and develop more difficult projects. The more recent gas discoveries are example of projects of this character.

The OME manage the production and export of oil and gas from between 10 and 15 oil fields. These fields are spread and divided into four main areas. The fields are locally administered at the site headquarter.

[1]Together, the seven sister formed what is commonly known as the consortium for Iran and consisted of Standard Oil of California (Socal), Texaco (Chevron), Anglo-Persian Oil Company (BP), Royal Dutch Shell, Standard Oil Company of New Jersey (Esso), Standard Oil Company of New York (ExxonMobile) and Gulf Oil

Company Goals

The OME has a strategy that aim to support a reasonable and sustainable development of the nation's resources and is a part of the Organization of Petroleum Exporting Countries (OPEC). The export revenue from the industry is approximately half of the overall gross domestic product and over 90% of the governments revenue, i.e., the nation is very dependent on the petroleum industry and the OME. Reserves estimates for the nation and the OME is more than 100 billion barrels per 2011 (BP, 2011). The production from the OME is restricted as the nation is a member of OPEC and the consisted in 2011 of 92% crude oil and 8% non-crude liquids.

The OME has a goal of developing technical solutions to enhance the recovery factor in the region. The exploration team has been in charge of initiating 3D surveys and 4D pilot projects. The company aim to produce new methods to solve complex data imaging problems and to decrease the uncertainty in prospect evaluation and reserve estimation, which is important for both exploration and field development activities. The vision of the operator is to unlock the potential of the nations hydrocarbon resource and its people. The company has several objectives that are linked to specified areas. The operator proclaims that it aim to develop infrastructure and reserves to meet market opportunities and at the same time emphasize challenging reserves and maintaining production capability. At the same time the operator acknowledge that trends predict the need of increasing production capabilities to meet the forecasted demand scenario. The company also aim to maximize reserves through a process based on values that include emphasis on exploration, enhanced technology and reservoir evaluation to reduce economic risk and technical uncertainty. In the HSE category the operator proclaim that it commits to ensure the health and safety of its people and that it protect the environment through strict policies and procedures that complies with local regulations.

Also stated as one of the objectives of the OME is directly related to the main topic in this study. The operator proclaims that it seek to be an organization that focus on performance and its customers and that this includes improving its core business services and other services that are non-core and that have the opportunity of being more efficient. OME also seek to focus on business processes that are value focused and emphasize low cost, quality, timing and flexibility. The operator state that the reason for this focus was related to previous experiences of project slippage and inefficient project management. By focusing on more efficient processes it can achieve reduction of project execution time, improve project management and streamline processes.

Most of the crude oil produced by the OME is sold on term contracts and the majority of the export volumes are shipped to Asian markets. The nation only consume a small portion of its total production, which in 2010 was approximately 15%.

6.3 The Operating Company on the NCS

The operating company on the Norwegian Continental Shelf is an international oil company. It has operations in more than 30 countries on several continents including operations in the Middle East, i.e., the operator is significantly larger than the OME considering geographical coverage. However, the ONCS is younger than the OME, which was established in the beginning of the 20^{th} century.

As a result of a cold climate, difficult weather conditions, complex reservoirs and large water depths offshore the operator states that it has learned a great deal through its presence on the NCS. The company is a licence holder on the NCS as well as being an operator, with operations in several locations on the NCS.

Focus Area

The ONCS proclaims that it has a strong focus on ethics and values, with their values being in the center of their management system. Ethics and values are also an important part when the company choose what supply company to use, requiring supply companies to sign an agreement that declaring that they will comply and operate with the same standards as the ONCS in areas such as human rights, ethics and labour standards.

As well as the OME, the ONCS has a strong focus on developing technology. The company sponsor several universities in Norway and in other countries. The operator has research and development programs throughout most of the oil and gas value chain, e.g., technology development in exploration areas, improve reservoir models to increase recovery, solutions for producing unconventional hydrocarbon resources such as heavy oil and shale gas. The ONCS is participating alongside other operators in the region to extend the lifetime of older wells and fields. The effort of making older assets on the NCS produce longer than first expected is considered an important factor in the work of increase the overall recovery on the NCS. As time proceed new technology is developed , thus increasing the possibility of technology progress being used to extend the lifetime of assets even further.

Work on mitigating the petroleum industry's effect on the environment is also an area of focus on the NCS. This is especially emphasized by the Norwegian government and the ONCS. The operator has ongoing research projects related to minimizing CO_2 emissions and climate gasses that affect the environment. The NCS also perform a great deal of research on produced water that is discharged to the sea to examine and reveal any potential risk it might have to the environment.

The ONCS emphasize improving the efficiency and lowering costs in the drilling phase. Cost efficiency is also mentioned several places in the research and development category of the company, as well as in the stated goal for technology management. The company state that it believe that it is important to focus on innovation and invention, and that it is important to achieve continuos improvement in all phases and processes to increase performance across the entire company. Business mapping can help operating companies discover areas of potential and enable continuos improvement to increase performance.

Processes and Income

Processes are central for the company and an integrated performance management process is used to translate ambitions and strategies into strategic objectives, KPI's, actions and goals. An integrated part of the performance management process of the ONCS is efficient allocation of resources, visualizing performance and establishment of processes that support continuos learning and improvement. KPI's are used by the operator to measure delivery and progress on strategic objectives, compare the performance to others and to address areas where improvement is needed. The operator also state that benchmarking KPI's are used to compare the performance of operations within the company to learn from leading entities. The technical safety monitoring system and safe behavior program in the company has the goal of achieving zero personal injuries. The operator focus on anti-corruption work, respect for human rights and employee rights.

According to the latest annual report of the company the proven oil and gas reserves of the operator has been reduced by approximately 11%. The serious injury frequency of the company has more than halved since the beginning of the century and the net income of the company has increased significantly from 2009 to 2011 (approximately 75%). However, an increase in net income is partly because of a higher average oil price in 2011 than in 2009. The average price of 2011 Illinois crude oil adjusted for inflation was 55.5% higher than the 2009 price of Illinois crude oil adjusted for inflation, with $87.33 USD and $56.15 USD respectively (West Texas Research Group (WTRG) Economics, 2011).

Countries in the Middle East		
Bahrain	Kuwait	Saudi Arabia
Islamic Republic of Iran	Lebanon	Syrian Arab Republic
Iraq	Oman	United Arab Emirates
Jordan	Qatar	Yemen

Table 6.1: Countries in the Middle East according to the geographical coverage presented by the International Energy Agency (2011)

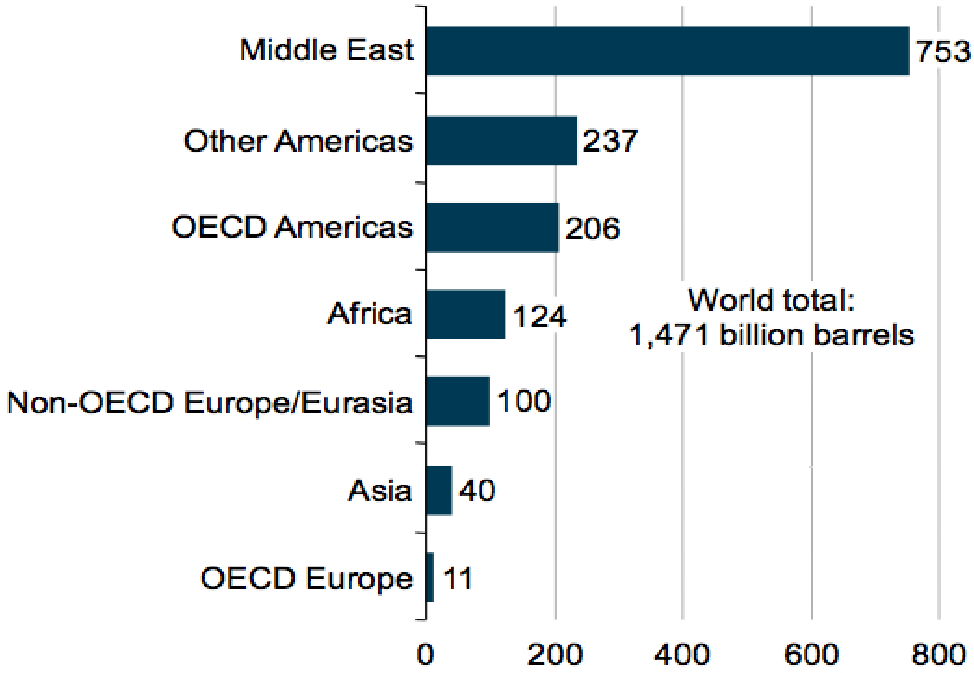


Figure 6.1: World proved oil reserves by geographic region as of January 1, 2011. Numbers in billion barrels (U.S. Energy Information Administration, 2011).

The Ten Oil Commandments
1. National supervision and control of all activity on the Norwegian continental shelf must be ensured.
2. The petroleum discoveries must be exploited in a manner designed to ensure maximum independence for Norway in terms of reliance on others for supply of crude oil.
3. New business activity must be developed, based on petroleum.
4. The development of an oil industry must take place with necessary consideration for existing commercial activity, as well as protection of nature and the environment
5. Flaring of exploitable gas on the Norwegian continental shelf must only be allowed in limited test periods.
6. Petroleum from the Norwegian continental shelf must, as a main rule, be landed in Norway, with the exception of special cases in which socio-political considerations warrant a different solution.
7. The State involves itself at all reasonable levels, contributes to coordinating Norwegian interests within the Norwegian petroleum industry, and to developing an integrated Norwegian oil community with both national and international objectives.
8. A state-owned oil company be established to safeguard the States commercial interests, and to pursue expedient cooperation with domestic and foreign oil stakeholders.
9. An activity plan must be adopted for the area north of the 62^{nd} parallel which satisfies the unique socio-political factors associated with that part of the country.
10. Norwegian petroleum discoveries could present new tasks to Norways foreign policy.

Table 6.2: The Ten Oil Commandments that shaped the NCS and how the oil and gas resources have been managed by the Norwegian government. (Norwegian Ministry of Petroleum and Energy, 2011[3]).

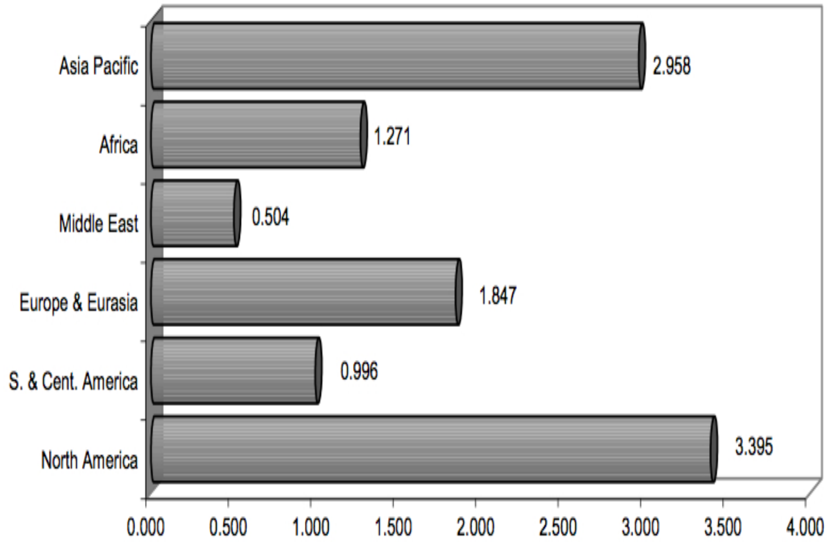


Figure 6.2: Equitable Crude Oil Reserves Depletion Index (2006). The index is defined as the ratio of the share of crude oil global production to the share of global proved oil reserves in a given economic, geopolitical or geographic region worldwide (Omowumi, 2007).

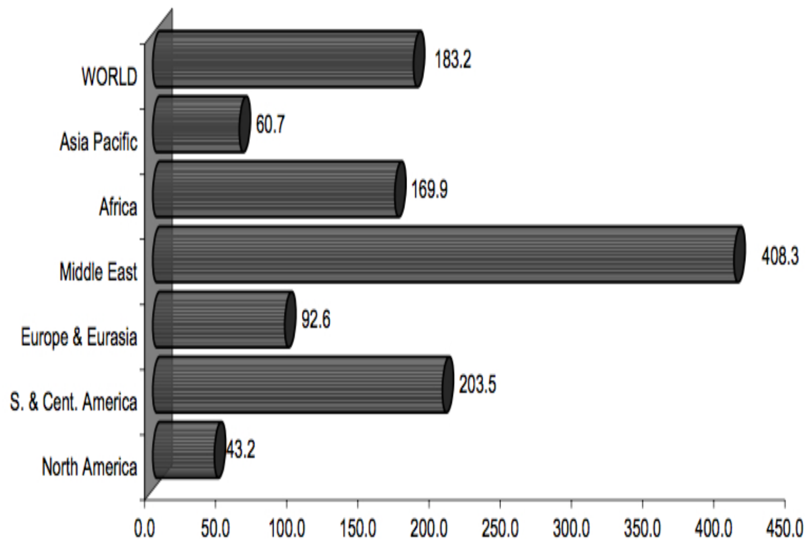


Figure 6.3: The reserve replacement ratio (RRR) measures the proved reserves added to the reserve base relative to the amount of oil and gas produced (Omowumi, 2007).

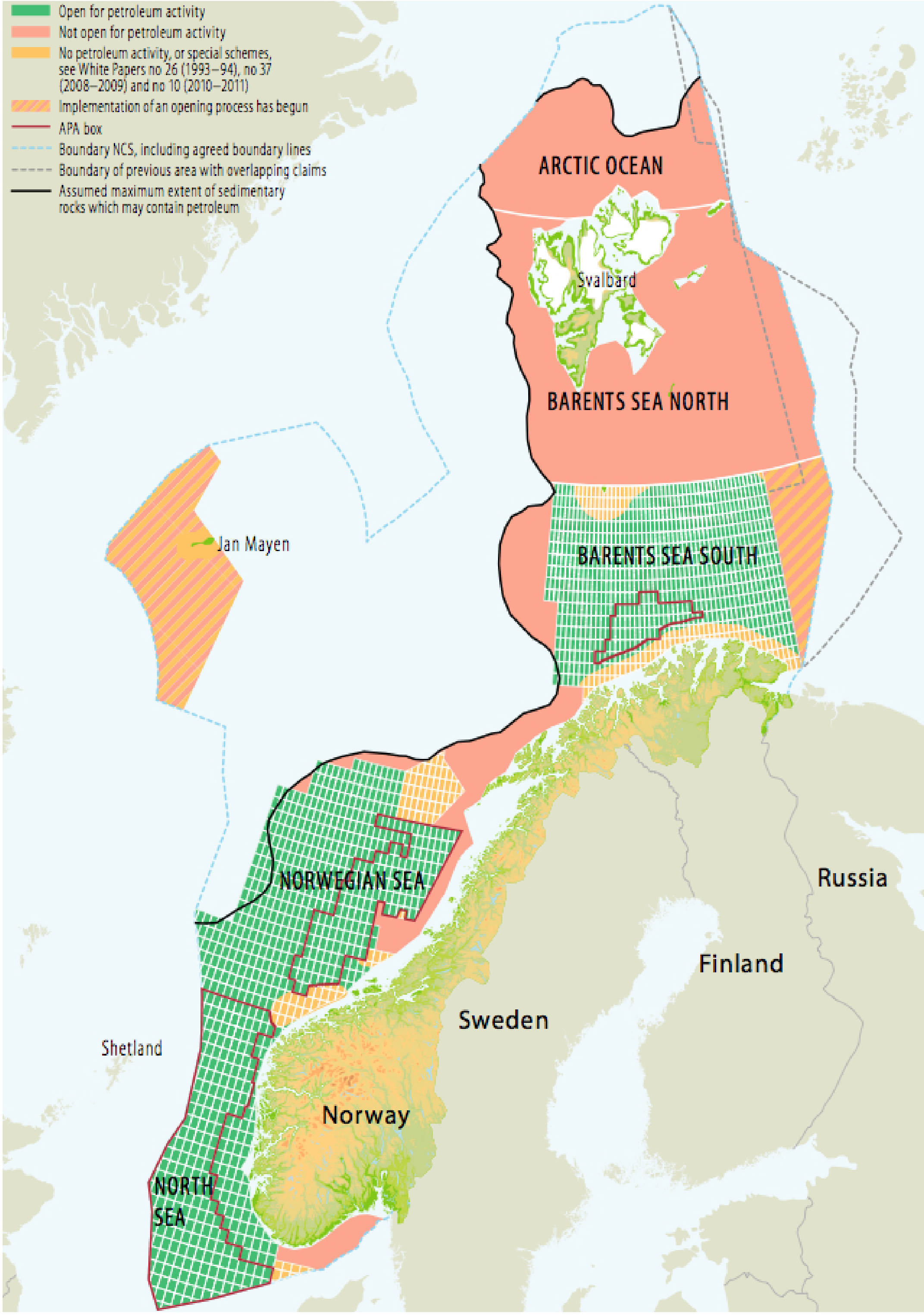


Figure 6.4: Regions on the Norwegian Continental Shelf (Norwegian Petroleum Directorate, 2011).

7 Results

Costs related to drilling and well are a major part of capital investments in the E&P industry and the upside of improving key processes is significant. In 2010, 47% of the investments in discoveries and fields on the NCS were costs related to drilling (Figure 2.20)(Norwegian Ministry of Petroleum and Energy, 2011[3]). The potential upside of a more effective WDP is significant and include assuring proper implementation of technology, increased efficiency in operations and increased quality in the planning phase.

To achieve a satisfying quality of analysis it is necessary to have a clear definition of the Well Delivery Process the study aim to improve.

As mentioned previously The well delivery process is defined as the set of key activities performed by the drilling department from receiving the request to drill from the field development team until the well is closed out and handed over to production. This was depicted in Figure 1.1.

Even though the WDP is strictly defined, it is also important to consider external factors that has an effect on the defined WDP. During the study it was found that several external factors have significant influence on the WDP.

The result chapter is divided into six sections:

1. Presents findings from the analysis of the WDP of the OME.
2. Presents results of the more brief WDP analysis of the ONCS. The section is important to be able to compare the two processes and present lessons learned from the ONCS.
3. Compares the analysis of the WDP of the two operating companies and look at differences and similarities.
4. Presents suggestion for how to improve the WDP based on the analysis. Improvement suggestions are a result of using business mapping and include the use of benchmarking.
5. Present a general strategy on how to implement improvements in the WDP.
6. Present a PESTEL analysis of future regional opportunities and challenges.

7.1 Analysis of the WDP of the OME

The analysis of the WDP of the OME is based an internal document with description of the WDP, business mapping of the drilling and well department of the OME and semi structured interviews. A total of 24 interviews of personnel at the OME were conducted in the period from mid-February to mid-April (2012), each one lasting for approximately 1.5 hours.

A process map of the well delivery has been constructed and is presented in Figure 7.1. Note that the OME differs between development wells and deeper and more complex wells. The complex well process is most similar to the process of the ONCS, thus presenting the process map of complex wells in Figure 7.1. A summary of the results are presented in Table 7.1.

Communication and Collaboration

When analyzing the WDP of the OME a lack of communication between the field development department and the drilling and well department was found. This is unfortunate as a close interaction and collaboration between the two departments are important. A representative within the drilling and well department state:

"I hear that the interaction with the field development team can be really bad"

It is important to avoid silo thinking and emphasize the importance of communication between departments. Current communication are in the form of letters, e-mail and phone, i.e., the operator lack of face-to-face communication and meetings between departments. Indirect forms of communication can lead to misunderstanding and misconception. It is also less efficient than direct communication. Silo thinking and lack of interdisciplinary communication often create negative effects in an organization.

Communication and collaboration between technical support and the drilling department is also poor. The main reason for the poor communication was stated to be a reorganizing of the company that happened not long ago.

A limited understanding of challenges and needs within different departments are important for a well functioning WDP. Findings reveal that the drilling department makes decisions with an insufficient amount knowledge of reservoir conditions and limitations. An interviewee stated that the drilling department should be more patient and take better care of securing well properties.

Similar findings were made within the field development department. An interviewee stated that the field development department does not take change in well scope seriously, i.e., the department lack consideration for the increased work from changes. However, the drilling department seem to understand that a certain rate of scope change is necessary.

Specific examples of lacking collaboration are several, e.g., the field development group wants to take reservoir samples but the drilling department does not, the field development department wanted to change the mud type, but no actions were taken from the drilling department.

An improved collaboration and cooperation between departments can result in synergy effects, which is useful for operators dealing with complex challenges. This would benefit the WDP significantly.

Change Management

A strong focus on change management and considering risk of change is important for operating companies in the E&P industry. What are the implications and domino effects of changes and how do we deal with it? By focusing on managing risks and implications of changes an operator is better suited to deal with unexpected situations that require adjustments.

The focus on change management in the OME was found to be insufficient. As depicted in Figure 7.1, no dedicated change management processes are incorporated in the process map of the well delivery.

To exemplify the importance of proper change management in the WDP it is useful to look at managing uncertainty in time estimates during drilling operations. Assume that 20 deep wells are planned drilled by the OME with an estimated time frame of 240 days per well. In total, the estimated time for drilling these wells is 4800 days. If the total estimate is 20% wrong it will lead an offset of 96 days. The worst case scenario is rig idle, i.e., a drilling rig procured in advanced has no well to drill and without work. Even though rig rates on land rigs in the Middle East is not as high as on the NCS it is something that the operating company want to avoid at any cost. Consequences of having procured a rig that is not on the move towards a well location or drilling can be compared with throwing money out the window. If change management is properly implemented in the WDP the operator would have an alternate solution ready, e.g., another well location standing by so that the rig can be used if any change in plans occur.

Lack of Decision Gates

Another finding from analyzing the WDP of the OME is a lack of active use of decision gates. Currently, there are no formalized gates in the drilling process requiring formal approval and work review. The organization lack review points that aim to discover poor decisions and ensure quality of work.

The WDP of the OME has decision points, e.g., when approving material allocation and procurement (Figure 7.1). However, during interviews it was fond that these points were not well known and often considered unimportant. Two statements exemplify that decision points are not poorly informed of within the drilling department:

"There are no stage gates"
"There are stage gates, such as the approval of budget proposals."

As mention by de Wardt (2010) it is of paramount importance that a system have the ability to filter out and avoid undesirable projects and detect elements that might cause problems in the future and are in need of re-engineering.

Rigid Long Term Planning

The WDP is a dynamic process that need to be able to implement certain changes. When revising the WDP of the OME a rigid long term planning procedure was discovered. A 25 year overall plan is set by a planning commission. This plan is broken down into a 5 year plan, a 2 year plan and a 1 year fixed plan. For each year that passes another year is added at the end of the 25 year plan, which again dictate the 5, 2 and 1 year plan. Long lead items are ordered as described by the 2 year plan.

A fixed planning structure without continuos revision and updates can potentially result in negative ripple effects and a poor change implementing procedure. It is difficult to predict trends and development of important elements, e.g., oil price and technology development. Long term planning can lead to missed opportunities and poor allocation of resources having a negative effect on the WDP. The dynamics of the industry has to be considered carefully.

Varying Degree of System Knowledge

A varying degree of system knowledge was discovered when analyzing the WDP of the OME. Significant variations were found when reviewing the use and perception of the governing documents and processes in the OME.

Even though many of the employees in the drilling department were aware that the governing documentation existed, the actual content is not known by everyone.

The quality of the current processes were perceived differently among staff. Some stated that process documentation was vague and not sufficient, while others stated that the process quality was good. The use of governing documents also varied. Some claimed that the processes are mandatory and others claiming that nobody use processes on a day to day basis. The lack of process ownership was also stated as being a problem.

These variations leads to discrepancies in the way of working, thus limiting learning and improvement significantly and compromising the WDP. A unified way of using governing documents and processes has significant potential and would benefit the WDP.

Deviating Targets and Contradicting Key Performance Indicators

A suboptimal use of targets in and between departments and teams in the OME was discovered. A lack of common objectives for the OME was found. Deviating targets across teams and departments is unfortunate for the quality of the WDP.

An example is how the drilling and well department use number of wells drilled per year as their primary target, while the field development team use gain of oil.

The field development department wish for high productivity wells and constantly emphasize high production rates and achieving minimum formation damage during drilling. Contrarily, the drilling and well department focus on following schedule and performing good during operations. However, performing good is based on what they are measured on, e.g., keeping a minimum rate of penetration and minimizing downtime.

An example of the problem of deviating targets and conflict of interest is how it resulted in a sub-optimal producing well for the OME. In an area with unstable formation and loose sands the high drilling pace resulted in formation damage and a compromised inflow environment. This situation should have been avoided. The conflict between number of completed wells on schedule and increased oil recovery should not exist.

An issue was also discovered with regards to key performance indicators - a way of measuring performance presented earlier in the study. Excessive measuring of performance can potentially have a negative effect working morale and lead to sub-optimization, as people tend to direct their attention towards assignments that they are measured in. Wrong employee focus can be the result of employees being measured on areas that are irrelevant for the company. The use of inappropriate KPI's was also highlighted by Perjons and Johannesson (2011).

An example is the contradiction between an increased oil recovery versus a focus on reducing costs. Projects to enhance oil recovery often require big investments. Exact effects of EOR-projects are often hard to predict and their amount of uncertainty significant. The result is often an unwillingness to proceed with measures to enhance oil recovery.

An example can also be retrieved from another industry. A factory producing steel pipes implemented several KPI's to increase performance. The most important KPI was the total amount of steel produced per day. An unfortunate outcome was how it led to an undesirable focus on producing as much steel as possible. It resulted in large amounts of big steel pipes being made and stored away in a warehouse. It also compromised other areas as an unwillingness towards producing smaller customized pipes was developed.

The mismatch in use of targets does not facilitate for mutually supporting operations. The focus on number of drilled wells can also lead to a limited focus on maintenance of older wells and workover operations.

The lack of common KPI's is challenge for the OME and reduces the quality of the WDP. It is found that several employees at the OME desire one common KPI across departments to support the WDP.

Deviating targets and use of contradicting KPI's have a negative effect on the well delivered and the WDP in general.

Recruitment, Turnover of Personnel and Training

The performance of organizations in the E&P industry is often closely related to the competence of their employees. As described in chapter 2, recruitment and personnel challenges are important challenges for operators. The OME is no exception.

The need for qualified personnel was expressed by several interviewees. The operator experience problems with qualified personnel quitting (retiring or leaving to work for other companies) and has difficulties with retaining employees with desired qualification. One interviewee state:

"Resources are a bottleneck"

The operating company has expanded during the later years. However, ambitions of the company are not reflected through increased manpower. This was emphasized by several employees. A specific example of a critical element related to the WDP is how personnel are needed in order to handle the increased number of rigs.

Training of resources that recently have been recruited is also important. Especially when resources are scarce. The need for training and learning routines and an increased competence development of engineers was discovered. An employee stated that there had not been training of engineers for the last five years. Another discovery is that there are no structured process for transferring lessons learned between personnel at the OME. All of these elements have a negative effect on the WDP.

Lessons Learned and Continuos Improvement

An important finding when addressing the WDP of the OME was the lack of processes and culture for capturing lessons learned. Missing implementation routines for improvements in the planning, execution and close out phase was also discovered.

The findings indicate some existence of processes aiming to capture lessons learned, e.g., available End of Well-report, documents including lessons learned distributed by e-mail, end-of-year lessons learned discussions.

The quality of the way lessons learned are captured in the organization is also perceived differently among staff at OME. Some employees proclaim that current procedures are satisfying, others state that there is a big potential for improvement. The need of more formalized processes to capture lessons learned was mentioned during the interviews.

This is confirmed when assessing the process map of the well delivery in Figure 7.1. The map show no dedicated processes for this purpose.

Consistent ways of capturing lessons learned create a foundation for continuos improvements. A lack of focus on lessons learned, transfer of information and improvement is unfortunate for the operator in the Middle East and the WDP.

High Rate of Change Orders combined with a Lack of Change Management

A major concern for personnel in the drilling and well department is the high number of change orders. Frequent changes in well design and specification are made by the field development department to optimize the well and its performance. The high number of change orders was said to result in less predictability in plans and suboptimal performance.

Further analysis revealed that problems with the high rate of change orders can be explained by how no formalized and comprehensive change management processes existed for change orders in the OME. The implications are many, such as non-optimal planning and scheduling, in addition to an increased potential for HSE incidents.

Within one budget year the field development team altered the trajectory of 113 wells from vertical to horizontal within one budget year. The drilling and well department had to make significant changes in every part of the WDP - a situation requiring high quality change management for it to run smoothly without any significant problems occurring.

Another factor that can influence the WDP is a change well scope, e.g., the OME needing a bigger rig to drill the well or having to increase the number of rigs to construct the well. The rig movement can be influenced by several factors, e.g., civil engineering elements and making new roads and electric grids. A lack of material and other logistic problems can also influence rig deployment.

Employees in the department are aware of the necessity of change in the WDP to optimize the final well product. The field development department need to perform reservoir simulations and incorporate changes because of increased geological information.

However, the high rate of change combined with a lack of proper change processes cause significant problems, e.g., increase in work load and stress. The only form of management discovered when addressing the WDP of the OME was linked to procurement of material.

A lack proper change management in several areas affecting the quality of the WDP of the OME was discovered, e.g., planning, HSE and procurement of new rigs. This is very unfortunate for the WDP as the drilling and well department is critical for assuring quality in the process.

Lack of Process Ownership

Improving processes is an effective way of increasing collaboration between departments. Several problems related to process implementation were discovered when investigating the WDP of the OME. Interviewing the OME's well delivery group it became clear that a discrepancy in process perception existed. Some employees meant existing processes were satisfying and followed, while other stated that current processes were far too general, not mandatory and not sufficiently good. However, some interviewees stating that processes are good and followed wanted to reduce the number of change orders significantly.

The statement contradict each other. If existing processes are good than the current change order percentage[1] should be considered optimal.

Different types of incentives is a way of promoting the importance of following processes are followed. An example is how the OME experience less trouble in an area in which they are measured on through several KPI's, i.e., HSE-related processes. Contrarily, the OME experience a significant amount of problems with the WDP. This is an area were departments lack rigid processes and do not have to report on KPI's.

Contractor Performance

A varying quality of performance among the current rig contractor's was also discovered.

An example from the OME is how the rig moving time in many operations is too long because the rig contractor had an insufficient amount of trucks to move the rig. An interviewee stated that rig move time should normally be approximately 10 days. However, at one point a lack of trucks led to a waiting period of 10 days.

[1]The change order percentage for the OME in 2011 was approximately 38%.

Working experience of rig crew is also a contingency. Experience vary significantly and is sometimes below international standard. One of the drilling rigs experienced a down time of 50% in 2011. Issues with low quality of rig equipment, low pay for engineers and poor facilities were also mentioned.

The consequences can be severe and have a negative impact on the WDP. Low performance of rig contractors can lead to rig idle, lower quality of drilled wells, increased cycle time per well drilled and risk related to HSE.

Use of Standardization and Focus on Maintaining Production

A great number of wells are drilled per year the development drilling department by the OME. The department utilize well categories and standardized well solutions to reduce planning time in well known geological areas.

Another discovery in the OME is how top management is determined on maintaining the current production rate in the years to come. It was revealed that this influence every part of the operating company, including the WDP. The focus is the main reason for the high number of wells drilled. It is also the reason for changes orders, i.e., the field development aiming to improve reservoir drainage and production rate.

The OME currently produce what can be considered as fairly easy accessible resources. However, because of management focus on maintaining the current rate of production it is reasonable to assume that the operator also have to produce the more complex and less accessible resources located in the region in the future.

Key findings from analyzing the WDP of the OME

Subject of Analysis	Findings
The WDP of the OME	• Lack of communication and collaboration between departments critical for the WDP • Lack of change management • Lack of formal and rigid decision gates • Lack of dynamic planning routines • Varying degree of system knowledge • Deviating targets and contradicting key performance indicators • High turnover rate of personnel, poor recruiting and missing training of inexperienced personnel • Lack of focus on lessons learned and continuos improvement • High rate of change orders • Troubles with implementing processes and lack of process ownership • Varying quality of rig contractor performance • Focus on standardization and maintaining current production rate

Table 7.1: Key findings from the analysis of the WDP of the OME.

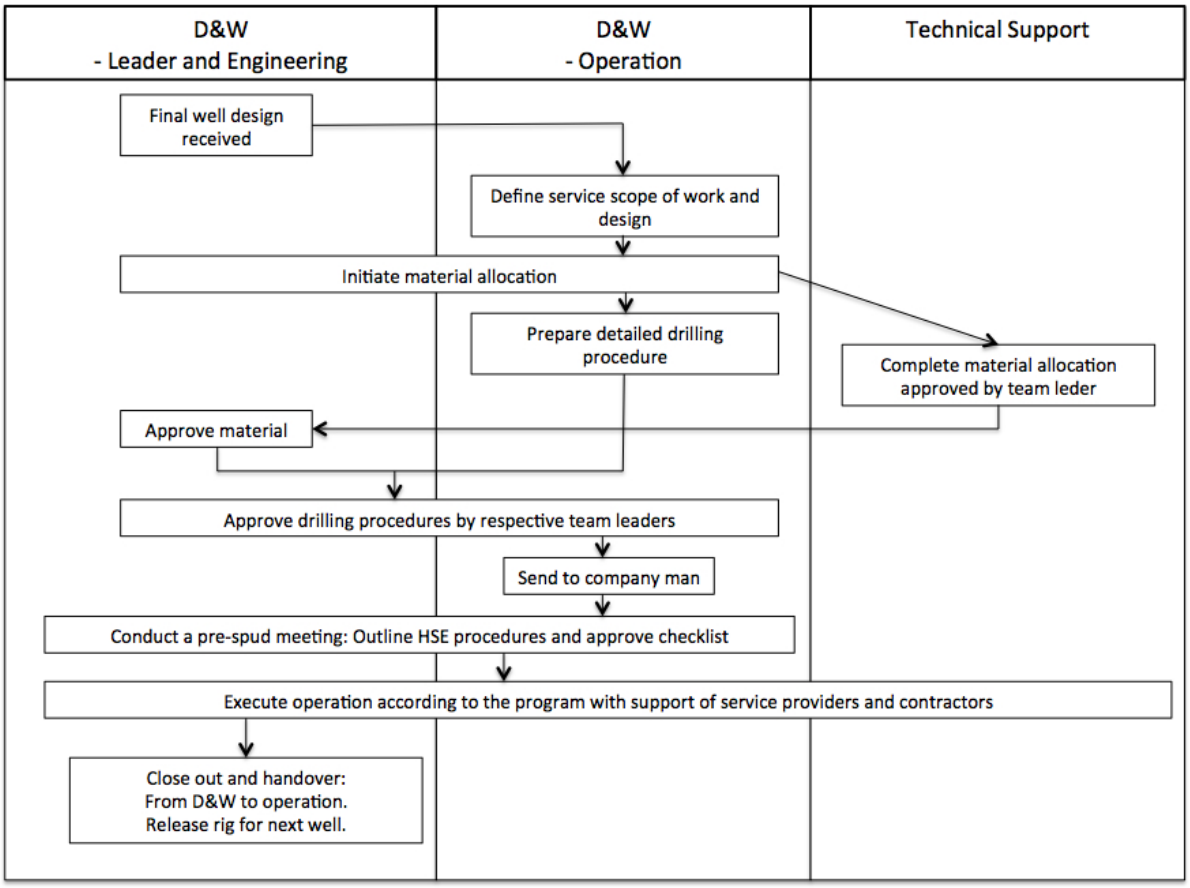


Figure 7.1: Process map of the well delivery performed by the OME.

7.2 Analysis of the WDP of the Operator on the NCS

To address lessons learned for the NCS it is necessary to review the WDP of the operating company on the NCS. The following sections present the findings as a result of the interviews of experienced personnel at the ONCS and analysis of the WDP

Investigation of the WDP of the ONCS were conducted by a combination of semi-structured interviews, well delivery process mapping and unstructured interviews that resemble regular conversation.

The unstructured form of interview included a set of predefined WDP topics and questions of interest, but the interviewee is given much room to answer freely. A total of six unstructured interviews of personnel at the ONCS took place in the period from March to May (2012). The interview sessions lasted for approximately 2 hours in average.

The processes related to well delivery in the ONCS are presented in Figure 7.2 and 7.3, in addition to the post activity process in Figure 7.4.

A summary of the analysis are presented in Table 7.2. The presented categories are similar to the ones presented in the analysis of the WDP of the OME.

Change Management Focus and Room for Improvement

It was discovered that a high rate of change orders in the WDP also existed in the ONCS.

For the ONCS most operations are located offshore. The ability to manage change is therefore important and critical for minimizing costs. The result has been an elevated emphasis on portfolio risk management within the operating company, i.e., being able to deal with a certain level of change in the WDP. Figure 7.3 depicts how change management is an important part of the integrated operation phase of the WDP. Change management is also an important part of the quality assurance, depicted in Figure 7.2 and Figure 7.3.

However, during interviews with experienced personnel at the ONCS it became evident that change management and related processes is an area of improvement for the operator. Concerns were raised towards a current tick-the-box mentality in change management processes. Indications suggests that current change processes in the ONCS lack tools that verify proper consideration with regards to analyzing and understanding domino effects of changes made.

Recruitment of Personnel and Proper Training

A lack of experienced personnel was found to be a challenge for the ONCS. The operator has therefore initiated recruitment processes to hire experienced drilling and well personnel. However, due to the aforementioned scarcity of qualified personnel in the oil and gas industry recruitment has been insufficient.

Simultaneously, successful exploration activity and an elongated lifetime of older fields has increased the need of personnel in the operating company. Inexperienced personnel has therefore been recruited.

The result is that the percentage of experienced personnel at the ONCS. This makes proper training routines very important for the operator.

It was found that the ONCS has established processes to facilitate for learning during the WDP. Examples are incorporation of post activities and evaluation points in Figure 7.4. It is important that these evaluation sessions focus on learning and training of inexperienced personnel in particular.

Another challenge discovered during the analysis of the ONCS is the existence of regulatory demands when assigning personnel to critical positions. Regulators dictate that employees in certain positions meet certain requirements, such as a minimum degree of experience, formal education requirements and course requirements. This makes focus on recruitment and training of personnel even more important for the ONCS.

Sufficient competence of personnel is important to achieve proper quality in the WDP.

Presence of Decision Gates and Process Ownership

The ONCS widely use development gates to guide their processes. These gates are equal to the stage gates described in the well delivery process section, i.e., they are considered holding points that need manager approval for the project to proceed.

Stage gates are used in field development and in the well delivery process where the main process consist of several individual stage gates, e.g., when developing a field or performing a well delivery. The gates are placed before, along and after the WDP. Decision gates are present at before the feasibility study, before the concept selection, before the planning process is initiated and after the operation is executed.

The bottom right corner in Figure 7.2, 7.3 and 7.4 demonstrate how process ownership is central for the WDP of the ONCS. Each process has an employee responsible for the process and the process owner is clearly stated.

Process ownership is important to secure quality in the work and assure that processes are followed. However, a shift in working procedures during the last years was said to weaken process ownership in the drilling and well department in the ONCS. The focus on reducing non-productive time in engineering departments has resulted in staff working on several project simultaneously, thus reducing the ownership individual engineers feel towards projects.

It is important for operating companies to be aware of the tradeoff between effective allocation of resources and the resulting reduction in process ownership. This awareness will improve the quality of the WDP.

Insufficient Communication Between Departments and Teams

Communication silos and room for improving interdisciplinary exchange of information was discovered during interviews of experienced personnel at the ONCS.

An interviewee stated that tight time schedules and multiple project involvement made it difficult to focus on information sharing and meeting attendance. This compromise communication between departments and teams within departments.

Individual teams within the drilling and well department are capable of transferring experiences successfully. Communication within teams is unfortunately not sufficient. Communication *between* teams is important because a large number of different teams exist within the drilling and well department.

A tool to improve communication and enable learning and improvement across teams is the the drilling and well database established by the ONCS. The database contains a lot of information on previous experience from operations and is frequently updated. However, a negative effect in form of a cut-and-paste mentality in engineering departments has ben an unfortunate outcome. It is important for the quality of the WDP that engineers have the ability to critically assess previous designs and solutions and carefully evaluate if it is possible to adapt elements from a previous design to a new one.

It is also important for the quality of the WDP that departments and teams within an operating company communicate and share critical information and experience.

Rigid Use of Processes

A finding from the analysis of the WDP of the ONCS is the rigid use of processes. Top management emphasize the importance of following processes to secure quality in operations. The focus on process quality and the importance of following them has increased after oil spill incident in the Gulf of Mexico in 2010 (Brewer and McKeeman). The rigidity is exemplified by a statement from one of the employees in the ONCS:

"If an employee does not want to follow our processes, he might as well go work at another operating company."

It is reasonable to assume that an increased focus on implementing processes of high quality and emphasis on proper risk assessment when changing operational procedures can reduce the chance of disastrous incidents occurring.

Dynamic Planning and Emphasis on Realistic Estimates

A finding from the analysis of the WDP of the ONCS is very dynamic and changing and planning regime.

Dynamic three month plans that are updated and revised in monthly meeting. All involved departments are represented at these meetings, including the ones participating in the offshore operations.

The ONCS also has a long term scope of eighteen months for operations, but as meetings are held the scope is narrowed down. However, the ONCS still has preliminary plans for the next eighteen months and a rough plan for the entire field lifetime. A formal stage gate is placed eighteen months before an operation is initiated, i.e., if any changes are to be made less than eighteen months before an operation the change request will have to go through a formal change process.

A result of focusing on dynamic planning is the change rate reduction in the WDP for the operating company. The rate has improved significantly during the last four year and is now at approximately 30% in the drilling and well department. One of the reasons for the improvement is the implementation of maturity requirements in their change processes, i.e., departments having a pre-defined time limit as to when they are allowed to implement changes in the well plan.

Another result of reviewing the WDP from the ONCS is the importance of assuring quality in estimates. Previously, approximately 50% of estimates were incorrect. The common procedure used then was the so called best case estimation technique, which use a optimistic time estimate. The operator experienced a significant increase in estimation accuracy when they started using an probabilistic estimation method. The estimation method provide P10, P50 and P90 time estimates. The probabilistic estimating technique in a cost context is described in Appendix F.

The combination of dynamic planning and quality in time estimates increase the quality of the WDP for the ONCS.

Management Focus On Maintaining Production and Reserve Replacement

During interviews it was discovered that top management in the ONCS has a strong focus on maintaining the current rate of production and keeping the reserves replacement ratio high.

Field specific production rates are monitored carefully by management, which has ripple effects throughout the entire organization and affects the WDP as well. Management responsible for fields have to meet frequently with top management to report on current production status. If production volumes are less than predicted it have to be explained carefully.

The stock value of the company is another factor increasing the focus. The stock value strongly reflects the company being able to maintain production and replace reserves or not. If production declines and reserves are not replaced the stock value of the company will decrease. This increase top management focus on maintaining production and replacing reserves even more.

Post Activities

A significant difference from the OME is that the ONCS has established post activity processes (depicted in Figure 7.4). These activities are conducted after the hand over of the well and aim to assure an the well is drilled as planned and perform as it is supposed to. The post activities also aim to secure proper documentation of the well delivery and include meetings, reports and evaluation session to assure that critical elements are properly highlighted.

Examples of critical elements included in the post activities include an evaluation report from the technology department of the ONCS, a final well report from the drilling and well department and a detailed analysis process if needed. Summary meetings with suppliers and internal post well meetings are also held by the drilling and well department. Results are included in the final well report. Post well activities also include an evaluation session 6 months after the well is finished and a KPI .

Post activities improve implementation of lessons learned and arrange for continuos improvement. This is positive for the WDP - especially since qualified resources are scarce and number of inexperienced personnel is expected to increase.

When investigating the WDP of the ONCS is an incident exemplify the important of securing and implementing lessons learned. The ONCS has been accused of a lacking ability to implement changes and improve their operations based on previous experience. In 2010 the operator experienced a serious well incident which was given extra attention because it had several things in common with a previous incident 3 years ago. The operating company received a lot of criticism from the Norwegian authorities and was accused of lacking ability to learn.

Batching and Standardization

Another finding from analysis of the WDP of the ONCS is how the company focus effective drilling solutions and standardizing well solutions to reduce cycle time.

The batch drilling concept was mentioned by several employees at the ONCS as an effective solution that can reduce drilling costs significantly. Batch drilling enable small low cost vessels to drill top hole sections and install christmas trees, while conventional drilling rigs complete the wells. Subsea christmas trees are installed directly after having drilled the top hole sections before the vessel proceed to the next well in the batch drilling campaign. As a result preparation for production can start earlier in batch drilling compared to conventional methods.

Experienced personnel also highlighted other batch methods that have been successful. Previous experiences has indicated that benefits can be harvested from utilizing vessels that specialize in a certain type of operations, e.g., batching of wells. The employee stated how a Transocean drilling rig that specialized in solely drilling wells by far delivered the three best wells on the NCS in 2011. A similar trend was registered for a Transocean rig that specialized in only doing subsea completion work. It was stated that the rig managed to complete a well in less then ten days as a result of specializing in subsea completion. The experienced employee also stated that batch drilling of well sections had been the reason for an overall success in a specific field development project was the reason.

It is important to highlight how important factors for success in batch operations are the ability to implement active learning processes and raise awareness of the importance of learning from previous experience. The success is also closely dependent on utilizing the same team to conduct the batch procedures because of the critical success element of continuos improvement and learning.

Standardization is another area has also been given a lot of attention by the ONCS. By targeting to develop marginal discoveries quick field development projects can move from discovery to production in a short amount of time.

Excessive Measurement and Deviating Targets

An extreme focus on measuring performance was found when assessing the WDP of the ONCS. The total number of performance indicators related to drilling and well activities exceeded 200. Indicators include lost time, meters per day drilled, liner running speed, number of wells drilled per wells planned and deviation percentage with regards to plans and time schedules. Service companies and contractors were also measured through the use of performance indicators. Employees and crews at the ONCS are measured in almost everything they do.

The presence of deviating targets between departments was discovered between the different departments in the ONCS. The parallels can be drawn to meet the OME who experienced similar problems.

A specific example is directly related to drilling operations in the operating company. It is common for drill teams in E&P companies to be measured on meters per day drilled during operations. Disregarding all other KPI's and organizational goals, the KPI implies that the best wells for the drilling department is vertical exploration wells without signs of hydrocarbons. This is off course not optimal.

Negative effects on the WDP include a rise in change orders, an increase in misunderstandings and frustration in the drilling and well department because of lack in communication. A lack of focus on common targets and working together can result in sub-optimal performance and create information silos within departments.

Key findings from analyzing the WDP of the ONCS

Subject of Analysis	Findings
The WDP of the ONCS	• High focus on change management, but with room for improvement • Scarcity of experienced personnel and difficulties securing sufficient transferring of lessons learned to inexperienced personnel • Presence of decision gates and focus on achieving process ownership • Insufficient communication between departments and teams • Rigid use of processes • Dynamic planning processes exist together with a focus of realistic time estimates in the planning process • Strong management focus on maintaining production and replacing reserves • Post activities focus on lessons learned and continuos improvement • Focus on standardization and batching • Excessive measurement and deviating targets

Table 7.2: Key findings from analyzing the WDP of the ONCS.

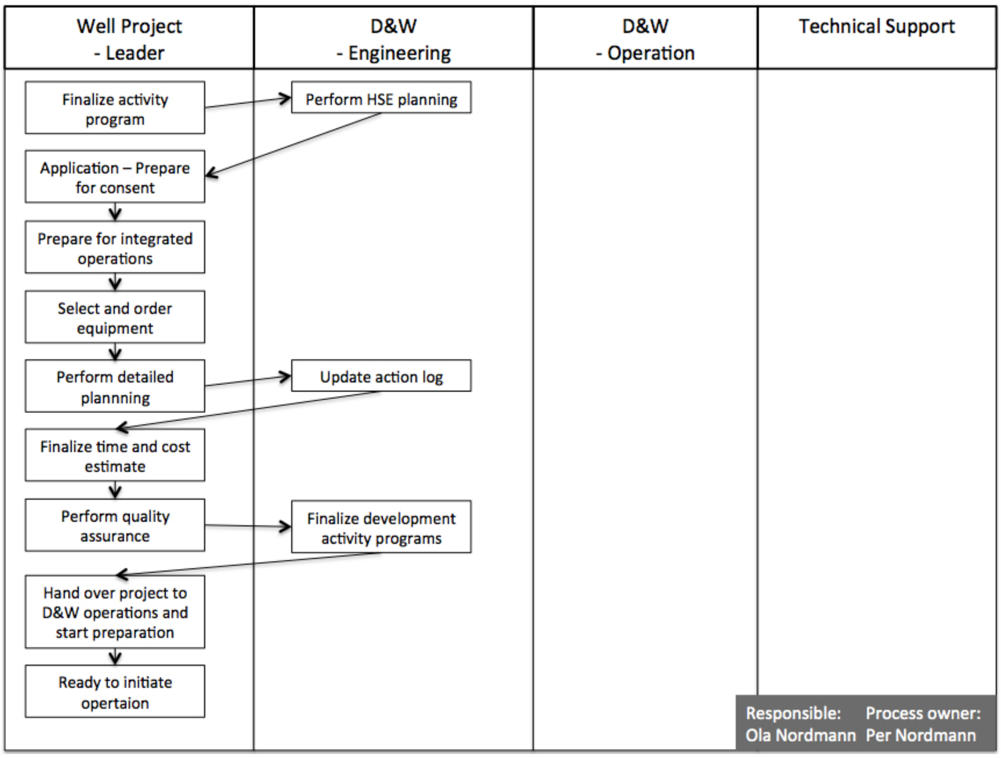


Figure 7.2: Process map of the first part of the well delivery performed by the ONCS.

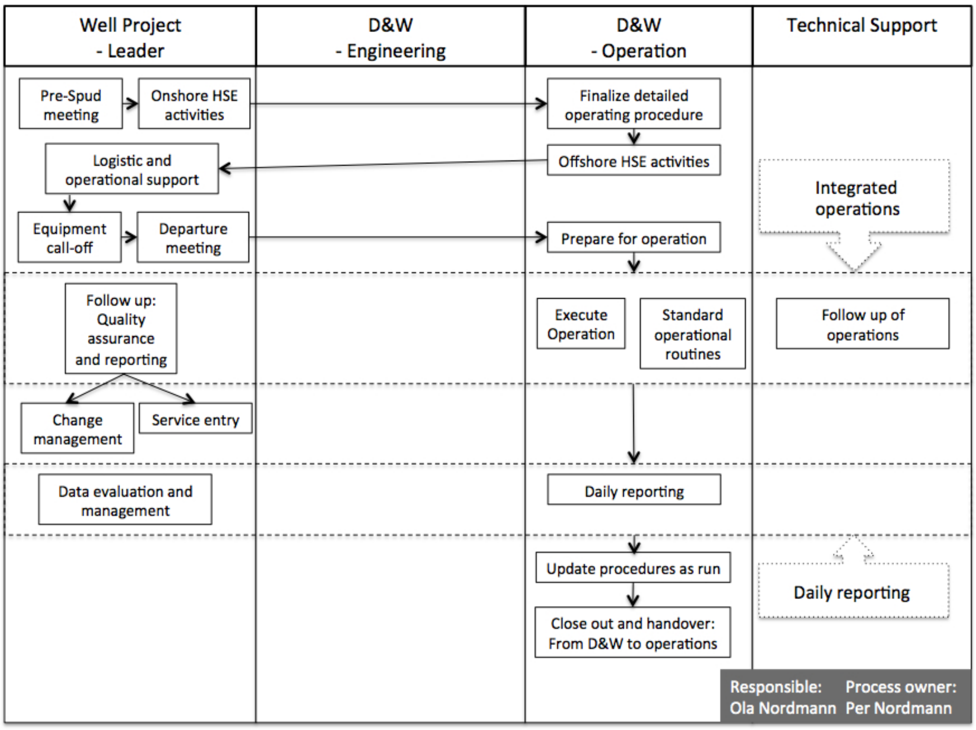


Figure 7.3: Process map of the second part of the well delivery performed by the ONCS.

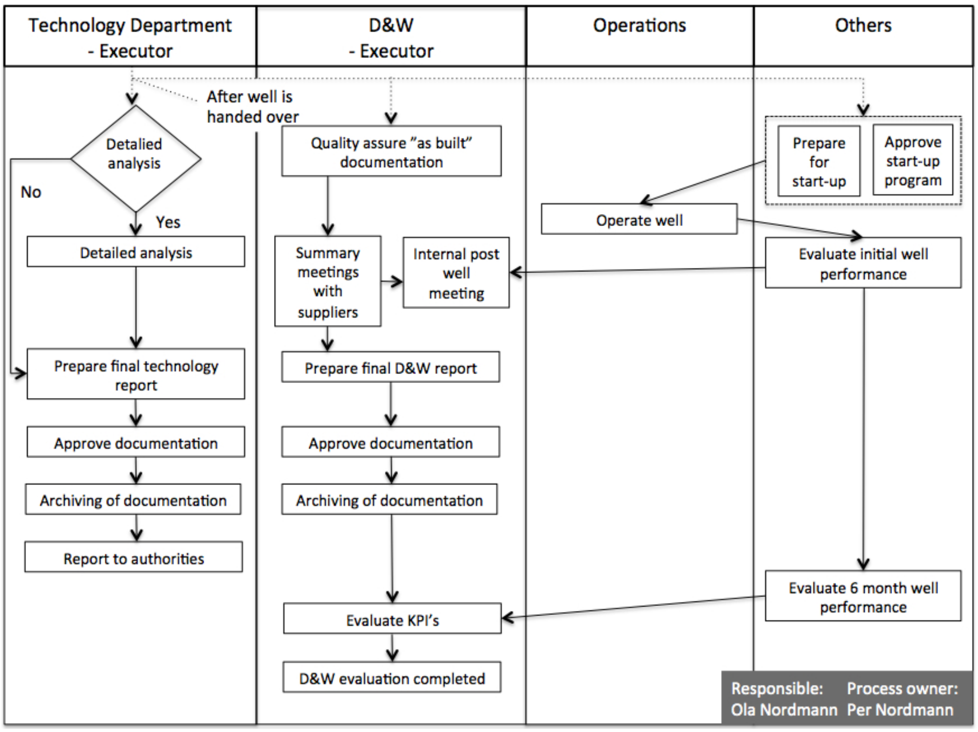


Figure 7.4: Process map of post processes related to well delivery performed by the ONCS.

7.3 Comparing Well Delivery Processes

Main differences and similarities as a result of analyzing and comparing the two WDP's are presented in the following section. Figure 7.5 visualize the main differences between the two WDP's. A summary of differences and similarities is presented in Figure 7.6.

Similarity in Historical Lack of Improvement Incentives

During meetings and discussion with experienced personnel in ONCS and PwC it was discovered that the improvement potential is significant for both operators with regards to making processes more efficient and of increasing their quality. It is believed that a historical lack of incentives to develop lean organizations is the main reason for the improvement potential.

However, lifting costs on the NCS are approximately twenty times higher than on the OME. It is therefore reasonable to believe that this discrepancy in lifting costs has created differences between the operating companies in the two regions with regards to benefits of making processes more efficient.

This was confirmed during analysis. The analysis of the WDP indicate that the ONCS has a bigger focus on achieving efficient operations and applying cost reduction methods. The process of the WDP of the ONCS show how integrated solutions are incorporated to improve cooperation and facilitate for simultaneous execution of activities during operation. The post activities including summary meetings with suppliers and a final well delivery report is another element that show how the ONCS focus on learning from previous experiences to achieve further improvements.

Similarity in Focus On Maintaining Production

A common problem for the ONCS and OME is how goals set forward by top management can compromise important long term issues.

This is exemplified by how the top management in both operating companies have prioritized to maintain a certain production plateau. These goals govern the direction of focus throughout the entire organization. The focus affects most departments and processes, including the WDP.

By focusing on maintaining production employees will not prioritize maintenance work that is not critical and choose not to perform well service. High focus on maintaining a minimum daily production rate compromise the focus on critical long term issues as maintenance work and repairs are in direct conflict with the main KPI, i.e., maintaining the daily production rate. The result is often referred to as the tsunami effect, i.e., postponing non-critical issues for a long period of time result in large numbers of urgent matters requiring immediate attention and undesired long term effects. A lack of well service and maintenance can cause sub-optimal well performance, non-existing maintenance work can lead to sudden increase in critical maintenance work needing attention.

The tsunami effect is currently affecting the NCS, where significant maintenance challenges are experienced at the moment. It is expected that the trend will continue in the years to come. The petroleum industry in the region is facing several critical challenges as the lifetime of an increasing number of facilities is extended. An extensive lack in maintenance has been been revealed. It has resulted in a lag in maintenance work, i.e., large numbers of urgent matters in need of immediate attention (Petroleum Safety Authority Norway, 2007, 2008, 2010). It is therefore necessary to emphasize both short and long term management. It is important that top management in operating companies is aware of the negative effects of an excessive focus on maintaining a certain rate of production. This is now emphasized by ONCS as a direct result of the occurring maintenance issues.

Similarity in Criticality of Achieving Continuos Improvement

In an industry where advanced technology and major investments require significant amounts of capital it is important to establish routines to assure that the company learn from previous mistakes and document experiences. Routines for assuring continuos improvements should exist in every operating company in the E&P industry.

Analysis revealed that this is a challenge in both the companies. It was stated for the ONCS that individual drilling teams operating on similar projects were able learn internally (within the drilling team) and improve as more wells were drilled. However, transferring lessons learned and exchanging experiences across drilling departments throughout the organization was described as unsuccessful, difficult and considered an area of improvement. Tools the ONCS had implemented to achieve continuos improvement include a database with lessons learned where previous incidents were recorded and categorized. A search engine was also linked to the database so that staff are able to check for similar problems if experiencing trouble.

Missing processes to implement lessons learned, expressed concerns with regards to communication between departments and poor sharing of experience proves that this is an area of improvement for the OME as well.

It is reasonable to believe that continuos improvement and transferring of lessons learned within the organizations are critical elements in the years to come. The main reason for the this is linked to the high rate of retirement of experienced personnel in the industry combined with recruitment of inexperienced personnel as presented previously. Operating companies that are unable to establish properly functioning routines for transferring experience and knowledge within the organization will most likely lose enormous amounts of valuable knowledge in the years to come. It will increase cost and reduce quality of processes and operations, including the WDP.

The operating companies therefore have to increase focus on transferring information between departments and personnel, in addition to emphasize learning. The predicted increase in complexity in future operations makes these factor extra important for the OME.

Similarity in Change Orders

The existence of change orders in the WDP is common for the two operating companies. Comparing the OME to the ONCS there is an approximate change order discrepancy of 20%. The average rate of change is approximately 50% for the OME and approximately 30% for the operator on the NCS. However, these percentages are based on different factors. The number of wells drilled between the companies are significantly different[2], as well as their definition of change.

The difference in change orders is a combination of several factors. One factor is how the ONCS has incorporated maturity in processes that result in freezing design elements after passing decision gates. The difference in change percentage is also a result of the ONCS having a greater focus on preparing for operations. The potential downside of applying the same amount of planning when drilling complex wells in the OME is that it might affect development drilling activities. Due to the current scarcity of qualified personnel it is important to emphasize efficient allocation of resources.

Operators should not focus on eliminating change in the WDP completely. By accepting a certain degree of change in the WDP it allows for implementation of new technology and elimination of poor solutions and other inefficient elements. This will favor the final product.

Similarity in Need of Focus on Change Management

An insufficient quality of change management seem to exist in the both operating companies, even though a discrepancy in focus was discovered. In order to better handle the dynamics of the WDP it is important for operators to increase focus on change management.

Revising the WDP processes it is found that the ONCS has a dedicated process element related to change management during operations in Figure 7.3. This is incorporated in quality assurance during integrated operations and aim to mitigate the uncertainties and understanding changes made during operations. The only form of change management discovered in the process map for the OME (Figure 7.1) is in the form of three dedicated process steps to assure proper material procurement management.

There are several examples of the importance of proper risk management and the downside of not understanding domino effects of change. The blow out incident in the Gulf of Mexico in April 2010 and the gas leaks at Gullfaks field and on the Snorre field on the NCS are incidents where changes during operations and insufficient change management and risk assessment resulted in serious incidents (McAndrews, 2011)(Marshall, 2011)(Stigset, 2011).

Proper risk management include fully understanding consequences of changes made and making sure that critical elements are not affected, i.e., that changes does not compromise anything of importance. "What will happen when I make these changes?"

[2]The number of drilled wells by the OME is significantly larger than the number of wells per year drilled by the operator on the NCS. The number of wells in development areas for the OME can be as high as 400-500 per year it total.

and "Are there any domino effects and what will be affected?" are effective ways of investigating if an employee is fully aware of the implications of the changes being made.

Also included in improving change management are elements such as collaboration between departments and communication. The topic of change management has been given attention during the later years, e.g., when discussing the new business context creating new requirements for leadership of deepwater organizations and when reviewing quantitative risk management in the Norwegian and UK oil and gas industry (Brewer and McKeeman)(Skogdalen and Vinnem, 2011).

Implementation of proper change management processes and a focus on high quality change assessment should be emphasized by the operators. This would increase the quality of the WDP in total significantly. If change had been properly assessed, the consequences of the aforementioned incidents could have been mitigated and perhaps even avoided.

Similarity in Existing Deviating Targets and KPI's

As discussed previously, both operating companies experience deviating targets and KPI's across departments.

Drilling and well departments in the two companies are measured drilling specific KPI's, e.g., meters drilled per day, actual drilling time versus planned drilling time, cost per meter. An excessive focus on drilling specific KPI's might compromise other important elements, such as HSE focus and emphasis on creating an optimal downhole inflow environment that will benefit production.

Another example of deviating targets within the two operating companies is their focus on maintaining the overall production rate. This can be harmful in a long term perspective and is discussed in Chapter 8.2. The following statement was uttered by an employee on the ONCS.

"There is a lack of KPI's supporting cooperation between departments"

The statement highlight how mutually supporting targets are currently missing at the ONCS. Similar opinions were uttered by personnel employed at the OME. The lack of mutually supporting KPI's compromise cooperation across departments. The findings reveal an area of improvement for the two operating companies.

Similarity in Scarcity of Drilling Rigs

In order to maintain production it is important for the two operating companies to drill a significant number of wells. A common problem discovered in both operating companies is how they experience difficulties in securing a sufficient amount of drilling rigs. Few available offshore vessels are currently available on the rig market (Figure 2.19), which is reflected by the elevated day rates on drilling rigs (Økland, 2011).

The scarcity of suitable vessels on the NCS is exemplified by how operating companies in later years have considered building their own rigs. This will secure that the rigs are able to handle the tough climate on the NCS and reduce rig uncertainty in drilling schedules. The scarcity of suitable onshore drilling rigs is reflected by how the OME starts procurement of drilling rigs years in advance. Onshore drilling rigs are booked before they know the amount of wells planned and where the drilling rig will operate.

Similarity in Focus On Standardization

Both operating companies focus on standardization to increase effectivity in operations and reduce costs.

This method is also referred to as fast tracking or fast track field development. Increased standardization can reduce the cycle time of projects significantly and impact the WDP through the use of standardized materials, designs and solutions throughout the process.

Standardization has been given a great deal of attention is because of its ability to make marginal development projects valuable to pursue. Previous studies conclude that fast track development has been crucial for development of marginal fields in many countries in different parts of the world, e.g., India, Norway and Egypt. A paper by Steffensen and Karstad (1996) clearly demonstrate the cost saving potential of the concept. The authors estimate that fast track development of the Norne Field on the Norwegian Continental Shelf reduced field development costs by approximately $1 450 million USD.

Difference in Focus on Continuos Improvement and Lessons Learned

Even though both operating companies need to improve implementation of lessons learned and continuos improvement, business maps and interviews reveal a discrepancy in how this issue is addressed between the companies.

An urgent need of establishing routines that facilitate for continuos improvement are revealed for the OME. Interviewees stated that a drilling report is constructed with the purpose of documenting lessons learned and improvements. The sharing of this report is very limited and the result is often that it is simply stored away.

Another finding from comparing the WDP of the OME and ONCS is that the operating company in the Middle East lack sufficient focus on critical post activities. The process map reveal that post activities similar to the ones existing in the ONCS are missing and that there are few activities and processes that emphasis sharing of experience and knowledge.

Difference in Level of Preparation

A clear difference in level of preparation between the OME and the ONCS was discovered. The ONCS has several dedicated preparation processes and quality assurance steps before operation is initiated, in addition to pre-offshore departure meetings.

Pre-spud meetings and detailed planning are conducted by both companies. However, and contrarily to the OME, the ONCS conduct frequent peer review sessions in the preparation and planning phase. Another difference in preparation is how the ONCS perform workshops to carefully go through the planned operation, i.e., DWOP and CWOP sessions. This is missing in the WDP of the OME.

Some of the differences are most likely a result of the ONCS activities being located offshore. The cost rate of offshore operations is significantly higher and the environment and crew is more vulnerable for any incidents occurring. Poor quality in the preparation phase can have huge negative effects in the form of increased costs and elevated chance of dangerous situations occurring, among other things.

Difference in Registering Data in KPI's

All international operating companies include the performance of their service companies in their performance monitoring. This is important to obtain a proper image of ongoing operations and is useful to analyze and detect areas of improvement.

However, during analysis of the OME it is found that contractor performance is not included in their statistics. This is unfortunate as it causes a skewed image of ongoing operations, making it difficult to give obtain a correct image of the quality of the ongoing operations based on performance indicators.

Differences in HSE focus

A difference in focus on HSE is revealed when comparing the process maps. The only HSE reference in the process of the OME is in the pre-spud meeting before operations are executed. Contrarily, the processes of the ONS has several dedicated HSE steps, e.g., onshore and offshore HSE meeting in step two and three in Figure 7.3.

It is reasonable to believe that regulatory authorities in the NCS region is a significant reason for the level of HSE focus by the ONCS. The Petroleum Safety Authority Norway can be described as the regulatory authority for technical and operational safety and for the working environment on the NCS in general. The role of the safety authority covers all phases of the petroleum industry in Norway, i.e., all elements from planning and design, through construction, during operation to decommissioning of fields. The authorities on the NCS require operating companies to implement HSE audits in all the same phases - including the WDP. The last process element for the technology department in Figure 7.4 show how the ONCS has a dedicated step related to reporting to authorities. HSE elements are also considered at decisions gates.

Difference in Planning Dynamics

Another difference discovered when comparing the operators is the difference in planning regimes.

By comparing the result of the analysis of the WDP of the two operating companies it is evident that the dynamics in the planning process is widely difference. The ONCS emphasize dynamic planning, both in short term and long term planning.

Contrarily to the ONCS, the OME is governed a relatively rigid planning regime put forward by a planning commission. The operator also seem to lack processes that facilitate for continuos revising of plans and interdisciplinary meetings that include relevant departments. A potential negative effect is how useful input and suggestions for improving operations are missed.

Formal decision points are found in the WDP of the OME. An example is the material approval step in Figure 7.1. However, the OME seem to lack decision gates and processes throughout the entire planning phase.

Difference in Process Rigidity

There is a discrepancy in how processes are followed by employees in the two operating companies. Findings from OME indicate that there is a big difference between employees with regards to whether or not they consider existing processes important and if it is mandatory that processes are followed.

The ONCS frequently communicate the importance of following processes and focus on processes throughout the well delivery phase. To assure that employees are committed they use RACI elements that distribute important roles and aim to improve process ownership. Decision gates are also used to revise executed processes. Because the OME lack formal decision points and rigid process the quality of the WDP is reduced.

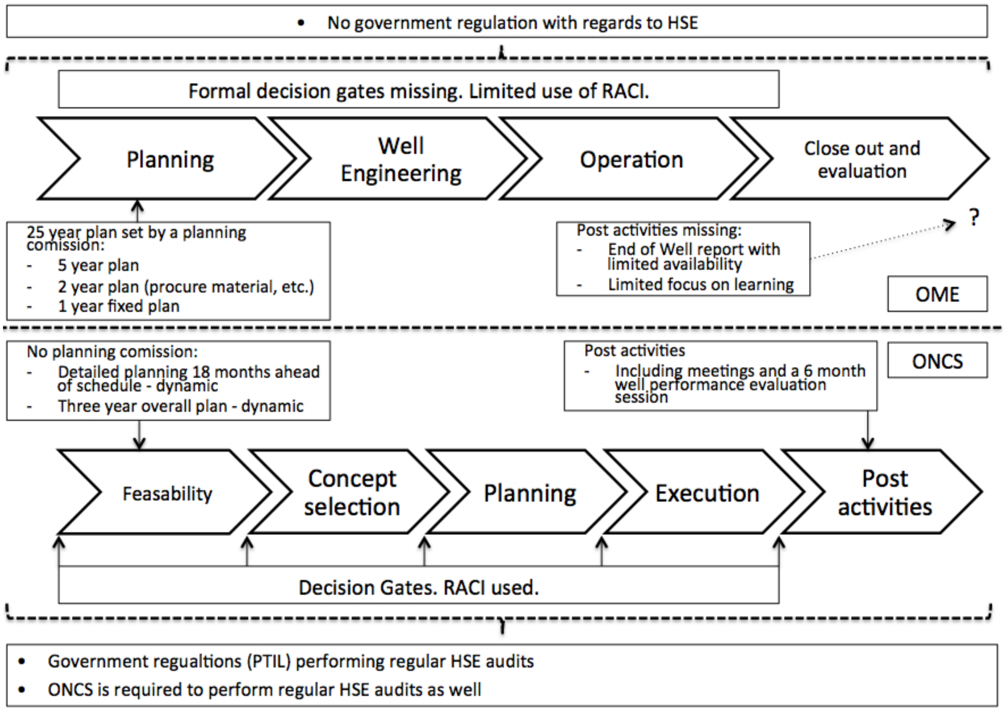


Figure 7.5: Important differences and similarities in the WDP between the OME and the ONCS.

Comparing Well Delivery Processes		
Differences		*Similarities*
The Operator on the NCS - Has implemented several measures to address the issue of continous improvement and lessons learned. - Operations mainly offshore. - Operations prepared more thoroughly than the operator in the Middle East. - Focus on HSE. - Dynamic planning.	**The Operator in the ME** - Insufficient focus on continous improvement and implementing lessons learned. - Operations mainly onshore. - Insufficient incorporation of data in KPI's. - Low HSE focus. - Rigid planning.	- Historical lack of improvement incentives. - Focus on maintaining production. - Can lead to a reduced number of workovers and maintenance. - Important to recruit qualified personnel, transfer knowledge and implement lessons learned. - Experience a significant change order percentage in the WDP. - Should increase focus on change management in the WDP and in general. - Deviating targets. - Scarcity of drilling rigs. - Utilize standardized solutions

Figure 7.6: Main findings from comparing the two well delivery processes.

7.4 Suggestions for Improving the WDP

The analysis of the WDP revealed several improvement areas. Specific suggestions with potential of improving the WDP are described in the following section. The suggested improvements are based on the aforementioned analysis. The improvement suggestions also incorporates lessons learned from the NCS.

Table 7.3 summarize the suggested improvements of the WDP for the operator located in the Middle East.

7.4.1 Establishment of Cooperation Forums

Interdisciplinary communication across departments is of paramount importance for operating companies in the E&P industry. The dynamic and complex character of the industry require conditions that facilitate and encourage communication.

A suggested improvement of the WDP of the OME is therefore to establish a cooperation forum between the drilling and well department and the field development department.

The suggestion is based on lessons learned from the NCS, where the operator hold regular meetings to debate important issues and relevant topics.

This will improve communication and give the two departments an opportunity to provide each other with feedback and discuss matters of interest. Forums can increase in exploitation of resources and potentially improve the rate of recovery. By improving communication the two departments will be able to structure their cooperation and improve exchanging of ideas and concerns.

7.4.2 Tools to Increase Information Transfer

Transferring lessons learned, sharing of experiences and continuos improvement are important for all operating companies. Several suggestions are made to increase information transfer in the drilling and well department to improve the WDP and sharing of lessons learned.

Regular Meetings Between Employees

A specific suggestion is to establish processes for transferring key information from experienced professionals to inexperienced ones, e.g., having regular one-on-one or one-on-two meetings between employees in different ends of the experience scale. These meetings can have a pre-defined purposes and subjects of mattes that can be proposed by both experienced and inexperienced personnel. This will give inexperienced personnel an opportunity to learn more about topics where they lack knowledge. Experienced personnel will be provided with the opportunity to share experiences that they consider important. Meetings can planned every on a regular basis, e.g., every second month. Another suggestion is that topics can be suggested by personnel with first hand knowledge about areas of importance. However, an issue related to implementing these meetings is time.

Both experienced an inexperienced personnel often have tight time schedules and no or little time to spare on a daily basis.

Encourage Information Sharing

It is also important to have an environment that encourage sharing of experience to avoid employees believing that it is favorable for their career to keep secrets, i.e., avoid sharing information and lessons learned. It is suggested that the OME create a company environment and culture that value and favor sharing of information between employees, teams and departments.

7.4.3 Dealing With the High Number of Change Orders

Frequent changes in well plans imposed by the field development department on the drilling and well department is considered one of the main improvement areas discovered for the operating company located in the Middle East.

However, it is important to emphasize that a certain level of change in the WDP is positive. Change should therefore not be completely eliminated. It is necessary for the field development team to perform reservoir simulations, improve history matching and incorporate geological studies as it increase quality of predications and optimize reservoir drainage. Change is a likely outcome, but overall results are most likely increased rate of production and improved overall recovery.

Workshop to Visualize Change Orders

An effective way of visualizing change effects in the WDP is to hold a risk management workshop attended by key employees in the drilling and well department and the field development team.

A specific change in the well schedule can be used as an example to clarify the domino effects of change. This is done so that the field development team is fully aware of all the work the drilling department must do when a change in well schedule is made.

To map, visualize existing problems and choose areas to focus on the workshop can also aim to construct a matrix consisting of key elements emphasized by key personnel employed at the operator company. The two axis will be consisting of ease of change versus element severity. The matrix is presented during a workshop with carefully chosen personnel ranking, where each key element is ranked according to its ease of change and severity.

The result is a holistic representation of problem areas that will make it easier to choose what problem to attack first to improve cooperation and benefit the WDP.

Benchmarking Change to Find an Appropriate Level of Change

An interesting area to investigate is the common level of change in the WDP among operating companies, i.e., what is the lowest change rate and what is acceptable? A suggestion is therefore to perform a benchmark study among operating companies to find the optimal level of changes in the well delivery process.

To be able to compare results among peers it is required that change is defined consistently throughout the companies being studied. To correctly analyze numbers and statistical data it is important that reporting methods are similar and comparable. If the reporting methodology is widely different for the companies investigated and consist of different criteria for reporting it is difficult to make conclusions solely based on the retrieved statistical data.

By comparing peers it is possible to find the lowest rate of change operating companies are able to handle. The ONCS proclaim that the company consider a change rate of 20% good, but also question what the cost of significantly lowering the current change rate if the industry benchmark is approximately 5%. If the return on investment (ROI) is negative then the marginal cost of lowering the change rate will most likely be bigger than the marginal benefit of lowering the change rate, i.e., companies will not proceed with initiatives to lower the change rate due to high costs.

To properly manage change orders it is important that departments understand the effect of change throughout the organization. It would benefit the operator and the WDP if an appropriate level of change is established and maturity levels in design processes are implemented.

7.4.4 Buffers to Support a Robust Organization

Focus on attaining a highly reliable and robust organization should be emphasized by the OME. By building a robust WDP able to cope with sudden change the operator will have the ability to better manage unexpected issues and proceed with a backup plan.

A dynamic WDP process can benefit from creating a buffer with important equipment, available staff and other elements to avoid operations being put on hold. If an unexpected event occur buffers can be used to avoid further delay in projects ready to execute immediately. This can benefit the OME as the operator in average drill more than four hundred wells per year.

Buffer elements should only be considered by organizations that experience high reliability in operations. An example of the positive effect is how buffers of drilling location and critical equipment can help avoid rig idle as a result of poor change management. The rig idle example is described in the change management section in chapter 7.1.

7.4.5 Revise Targets and Performance Indicators

It is suggested the the OME revise the use of KPI's and distinguish between ordinary and less important performance indicators. Not every performance indicator should be considered key. The OME is advised to consider the number of performance indicators and decrease the amount if considered favorable.

An excessive use of performance indicators can result in wrong focus during operations, e.g., employees only caring about tasks they believe will benefit themselves or the team. This is especially true if all performance indicators are considered key. The end result can harm the operating company and cause a lack of focus on other important areas, such as performing safe operations. This will decrease the quality of the WDP.

7.4.6 Establish Targets that Favor Mutually Supporting Operations

It is suggested that the operator communicate the importance of working together to benefit the OME as a whole.

A suggestion is to implement targets, establish incentives and KPI's that facilitate mutually supporting operations across departments. This will mitigate the negative effects of employees and departments focusing on less important performance indicators, reduce the effect of any contradicting KPI's and deviating targets. This should also be considered as a suggestion to improve the WDP of the ONCS.

7.4.7 Increase the Focus on Change Management

The analysis of the WDP of the OME revealed a lack of change management incorporated in the current WDP. The importance of proper change management is discussed in section 7.1.

As wells grow older the frequency and criticality of integrity issues increases. This provides concerns with regards to managing the reduction in integrity of older wells in the Middle East and on the NCS. It is important that operators focus on integrity changes as well as managing domino effects of changes in the operational procedure. Change management focus must consider several elements throughout the value chain.

Clarke and Goodisman (2000) also highlighted the importance of change management. The authors emphasize that operators should focus on reducing the number of serious incidents, as they are extremely costly and might have severe consequences to the environment.

An example of how change management is included in the WDP of the ONCS is depicted in Figure 7.3, where it is a central part of integrated operations.

It is suggested to increase the focus on change management and implement dedicated change management steps in the WDP of the OME. It is important that the implemented change management processes assess the criticality of the change being made. The change process established should not be able to complete before the risk of change is properly evaluated. Proper change management is especially important as the operator experience a high number of change orders in the WDP.

7.4.8 Mandatory Approval Points

Implementation of changes aiming to improve certain areas of an organization is not an easy task. Top management have to communicate the importance of the changes being made.

Introducing mandatory approval points in processes is an effective ways of making sure that changes are followed, e.g., making it mandatory for line managers to approve any changes in work processes. This will mitigate the chance of inexperienced personnel making mistakes in different phases of an operation.

However, it is important to maintain a dynamic operation that is able to cope with changes an unexpected incidents. An undesired outcome of implementing too many trigger points for formal approval is development of an inefficient organization. It is likely that frequent and complicated bureaucratic elements will act against their purpose and prevent improvement.

7.4.9 Implement WDP Tools and Validate Their Use

Examples of useful tools in the WDP have been discovered during the analysis of the WDP of the ONCS. Several tools were also mentioned by de Wardt (2010). The most important tools to consider are:

- RACI matrices complimenting the WDP to improve process ownership and clarify important process roles.
- Standard design supporting and improving construction of standard wells.
- Peer reviews to support and increase construction of complex wells.
- Conduct DWOP and CWOP meetings to prepare for operation
- Probabilistic estimation methods to improve planning.

It was found that the OME the lack of decision gates and does not performing on paper exercises. As a result it is suggested that the OME investigate their use of tools in the WDP and ensure that the proper ones are implement in their WDP.

7.4.10 Suggestion Based on Lessons Learned from the NCS

Lunch and Learn

A suggestion that supports transferring of information is based on lessons learned from the ONCS. Common lunches where several departments participate can help highlight important and relevant subjects. Lunches can have a dedicated subject of matter that is presented by an experienced employee.

Newsletters

Another lesson learned from the ONCS include a suggestion of publishing a regular newsletter in the drilling department. The purpose of the newsletter is to inform employees of the latest and most important operations and highlight critical elements, lessons learned and improvement areas. The newsletter can also include key performance indicators relevant for the department, e.g:

- Meters per day drilled for different business units
- Meters per day drilled per installation
- Casing/liner/screen running rate in joints per hour per rig
- Serious incidents frequency
- Fallen objects frequency

If the published newsletter ties several departments together it might benefit interdisciplinary cooperation and strengthen team spirit.

Decision Gates

A lesson learned from the ONCS that can improve the WDP significantly is implementation of decision gates. The significant benefits from using decision gates has also been emphasized by de Wardt (2010). Benefits from implementing decision gates include:

- Breaking the WDP into stages so that each process is easy to identify
- Provide the opportunity to develop, plan and supervise operations within a predefined framework
- Assure that well delivery phases are revised carefully before it is decided if the operation can proceed forward to the next stage
- Clear definition of deliverables
- Secure that important competence is included in the processes

Establish Rigidity in Processes

If processes are not followed there is no reasons in developing and implement processes to secure proper execution of the well delivery process. As mentioned, findings from OME indicate that processes are not sufficiently followed and focused on.

An effective way of avoiding this is involving top management. If following processes is mandatory it is important that it is well known throughout the organization. Staff have to know they are not able to chose whether or not to follow processes.

A suggestion to improve the WDP of the OME is therefor to clearly communicate the importance of following processes within the company. It is also suggested to make it mandatory for employees to follow the established processes.

Rigid processes will also help establish a common terminology that is consistent across the operating company. This will assure a common language and a common understanding of existing processes and how they are executed within the organization. An element that is important to emphasize is that the established processes are carefully coordinated and executed according to each other.

Implementation of RACI charts will distribute important roles and improve process ownership. Decision gates should also be incorporated in the processes, as mentioned previously.

The benefits of rigid processes was expressed during interviews of an employee at ONCS. The employee had experienced that if processes are not formalized and made official by top management the result is often that they are not followed.

Increase Dynamics in Plans

A lesson learned from the ONCS is the benefit from having a dynamic planning regime. It is therefore suggested to implement more frequent meetings between departments in the OME to discuss and revise important elements in the WDP, e.g., critical well design elements, update schedules, problems occurred, change in scope because of new technology and improved reservoir simulations.

It is also suggested to revise the necessity of the planning commission and the long term planning horizons of five and twenty five years. It is important to have preliminary plans for the future lifetime of assets. However, a lack of dynamics in plans can result in missed opportunities and might lower the ultimate recovery rate.

Post Activities to Improve Lessons Learned and Achieve Continuos Improvement

The analysis of the WDP of the OME revealed missing processes that focus on feedback and continuos improvement. This is especially unfavorable for an operating company that has expressed concerns about the level of experience in the organization and struggle with a high turnover of experienced personnel. Continuos improvement is also an area of improvement for the the ONCS. However, analysis found that they currently have a bigger focus on the issue compared to the OME.

An important lesson learned from the ONCS is related to the operators utilization of post activities. It is suggested to implement similar post activities to improve the WDP of the OME. The post activity processes should include the following elements:

- A meeting that assesses the previous operation and the need of detailed analysis of the operation.
- Meeting between departments involved in the WDP to evaluate the performance of the well, discuss lessons learned and suggest improvements.
  The first evaluation sessions should be held directly after the well has been delivered. The second evaluation sessions should be held some time after the well has been delivered, e.g., four months after.
- A post operation meeting with involved suppliers with focus should on lessons learned and suggest improvements.
- Evaluation of relevant KPI's.
- Routines that ensure the construction of post well delivery reports for important departments. The reports should include lessons learned and suggested improvements.
- Processes should include RACI elements to provide process ownership and clarify roles.

It is suggested that the OME implement similar post activities. It is believed that the suggestion support continuos improvement by critically revising previous operations and enhance focus on lessons learned and sharing of critical information.

The potential benefits from implementing the presented suggestions for improving the WDP of the OME are many. The most important are:

- Departments and teams being better prepared for executing operations.
- Increased process ownership.
- Validation of an appropriate level of change in the WDP.
- Process consistency.
- Increased focus on HSE.
- Securing the proper quality in planning and execution of critical activities.
- An improved focus lessons learned and continuos improvement.

Suggestions for improving the WDP

Improving the WDP	Suggested improvements
Lessons learned from the NCS	• Establish cooperation forums between field development and drilling and well • Tools to increase information transfer: -Regular Meetings Between Employees -Encourage a company environment and culture that value sharing of information • Dealing with the high number of change orders: -Workshops to visualize domino effects of change -Benchmarking to find an appropriate level of change • Establish buffers to support a robust organization • Revise targets and performance indicators to remove compromising elements • Establish targets that favor mutually supporting operations • Increase the focus on change management • Implement important WDP tools and validate that they are used • Implement mandatory approval points to make sure processes are followed • Arrange common lunches to increase information transfer and highlight important subjects • Publish newsletters to increase information transfer and highlight important subjects • Implement decision gates in the WDP • Communicate importance of existing processes and establish rigidity in processes. • Increase dynamics in plans • Implement post activities to improve lessons learned and achieve continuos improvement

Table 7.3: The table summarize the suggestions for improving the WDP of the OME.

7.5 Stepwise Implementation of Improvements in the Well Delivery Process

Several improvements were discovered for the OME. By implementing initiatives presented previously the WDP of the operator in the Middle East can harvest several long term benefits.

The following section propose a general strategy for how to discover and implement improvements in the WDP with the help of an opportunity progression system. The system help ensure quality in the implementation process and contribute to fulfilling the aforementioned objectives. The entire system consist of three phases. One opportunity phase, one identification phase and a implementation phase. Each phase consist of different activities and aim to result in a deliverable product.

The opportunity phase consist of revealing issues and challenges associated with the WDP. These findings has been presented in the previous sections.

Identify Parameters and Evaluate Useful Categorization Systems

The following stage is the identifying phase. This phase aim to identify parameters useful for categorizing, e.g., complexity, cost, impact. An evaluation of any existing well categories is also performed. Examples of different well categories are similar to the ones is presented in the section on the WDP, such as repetitive wells and strange wells.

Analysis of relevant cycle times, construction performance matrices and a review of capabilities of existing systems, processes and departments are now carried out. The constructed performance matrices rank processes and link them to strategic objectives of the upstream activities of the company. The end result is a map showing how the current status of well delivery process and how revealed challenges are related to the current WDP.

Also included in the phase is the defining of several important elements in the well delivery process, e.g., defining standard processes and important roles in each one of the well categories that were identified earlier, defining a well delivery stage gate and a continuos improvement system and defining pre-requisites.

The last service in the identification stage is assisting the work with obtaining results so far and preparing for the execute stage by development of implementation, change management and communication plans.

The deliverable products in this phase are many and consist of several improvements. The stage aim to deliver performance metrics, well categorization systems and a future well progression and delivery system for each of the identified categories. The deliverables can also consist of RACI matrices and an evaluation of any well delivery stage gate system, key enablers with regard to implementation of technology and analysis of relevant standards.

Another outcome is a continuos improvement framework to capture lessons learned and an implementation plan with detailed information on key activities, different phases, resource requirements and important dependencies.

Also delivered in this stage are implementation of plans that include all the necessary activities, phases, resource requirement and existing dependencies.

At the end improvement processes, program and plan for improving and handling communication in the new operating model is presented. Included in the communication program and change management plan are strategies for training and coaching new employees.

Execute Implementation

The third and final stage of improving the WDP aim to highlight and implementing the revealed improvements. The first step in the final stage consist of finalizing and launching of communication plans that will engage stakeholders and inform them about the improvements, e.g., new well categorizations and associated changes in the process.

Critical impact areas given the highest priority. It also important to facilitate and help training of personnel that will use the operators new well delivery model and incorporated tool. This require continuos monitoring and coaching to assure a correct implementation to achieve the full potential of new processes and tools. Important areas are metrics and continuos improvement.

Awareness sessions are also useful as a tool to easy implementation of the new WDP. Sessions will help create awareness among the central actors and stakeholders in the operating company. The execute stage ends with the operator preparing for operations.

Similar implementation programs can be constructed for improving other important processes in an operating company. Several programs can also be elements in a full scale implementation program to improve large parts of an upstream organization.

Examples of critical processes within in an operating company that can have significant process improvement potential are the cycle from exploration production, the operating model for research and technology, the production efficiency improvement process, the HSE operating model and the supply and procurement management process.

Goals and primary objectives of an implementation program can be to improve process effectiveness that aim to deliver changes resulting in long term benefits such as establishment of awareness of the operating model, improvement of efficiency when the new operating model is fully integrated in the business, in addition to clarification of responsibilities and accountabilities between important teams.

7.6 Future Opportunities and Challenges

Differences in opportunities and challenges facing the regions as they prepare for their future challenges are several and varied. To address these opportunities and challenges the aforementioned PESTEL framework is used.

The following section presents the analysis of future opportunities and challenges for the two regions. The results are summarized in Table 7.4, 7.5, 7.6 and 7.7.

7.6.1 Political

Opportunities

An increased percentage of world proven oil reserves in the Middle East is likely to result in increased political opportunities in the region. The trend was highlighted by Omowumi (2007).

Several future political opportunities are present in the NCS region. Norway has a stable political environment with a clear governance and segregation of duties with regards to legislation, supervision and ownership. A competitive E&P market is also present and no legislation favor local suppliers or local content, which is positive and creates an friendly business environment. An important opportunity is the upcoming Norwegian parliament election taking place in 2013. The outcome of this election can decide wether or not to initiate processes that can result in opening the areas outside of Lofoten and Vesterålen for exploration activity.

Another political opportunity in the region is how recent political negotiation between Norway and Russia resulted in an intentional pact for dialogue on joint management of oil and gas resources in the recently delineated Barents Sea area. Enormous amounts of exploration acreage are available, providing the energy region with several opportunities in many years to come.

Challenges

Political challenges in the Middle East include a more volatile political environment with less clarity of segregation of regulatory duties. Dominant national oil companies are often involved in legislative development and are able to affect regulatory roles as there are close ties between the oil companies and ministry. There are more frequent monopoly situations and local suppliers are often favored. In addition, it is not uncommon for political appointments to interface with business.

Political challenges of particular relevance in the Middle East is the recent political development in the region. An unstable political environment can have negative ripple effects and result in challenges with regards to cooperating agreements with international oil companies and make recruitment more difficult.

Challenges for the ONCS with regards to politics are fewer as the political environment is relatively stable and predictable. However, the combination of high tax rates[3] and high costs can result in marginal discoveries and development projects being put on hold or cancelled by operating companies. Two specific examples of political decisions increasing costs and affecting marginal projects were presented in the recent white paper put forward the Norwegian Ministry of the Environment (2012). The paper states, among other things, that the Norwegian government demand all actors on the NCS to consider electric power from the main land when planning to develop offshore discoveries and significant reconstruction work on older installations. The second example is how the government decided to increase the CO_2 fee by 95.7% (an increase of 200 NOK) to a total of 409 NOK per ton of CO_2 outlet from the petroleum sector. When fields move into the declining production phase (tail production - depicted in Figure 3.2) the amount CO_2 outlet per barrel of oil is significantly higher than in the early phase of production. The worst case scenario because of increased CO_2 fees is advanced decommissioning phase and a reduction of the recovery rate in the region.

7.6.2 E - Economic

Opportunities

The current energy scenario suggest a bright economic future for both the NCS and the Middle East. A high future demand for oil and gas elevates the prices of hydrocarbons. Prices are expected to stay relatively high and stable in the years to come.

Another economic opportunity is the apparent presence of a significant cost reduction potential in the E&P industry.

The lifting cost in the Middle East is a fraction of that on the NCS. It is reasonable to believe that the performance improvement opportunities are greater for companies in the Middle East in the future because of a lack of competition and improvement incentives.

The Norwegian government has created a sovereign wealth fund to protect the local economy and mitigate inflationary effects. Continuos proper management of income from the oil and gas industry is predicted to create future economic opportunities.

Challenges

Challenges with regards to economics are also present in both regions. A common future challenge is how the regions are vulnerable for a drop in oil and gas prices. It reasonable to assume that the NCS region is more vulnerable for a fall in oil and gas prices because of high lifting costs from offshore operations.

The Middle East region has in average little focus on creating alternative industries and facilitation of synergies across industries. A future challenge will be to find alternative industries that can help develop the region when the petroleum industry becomes less important.

[3]The combination of an ordinary profit tax of 28% and a special petroleum tax of 50% result in a total tax rate of 78% for operating companies on the NCS

Even though personnel costs are a minor concern for operating companies it is worth mentioning how an aging workforce will result in higher pension costs in the future.

7.6.3 S - Society

Opportunities

Social trends provide opportunities for the regions. The widespread use of internet and digital media reduce boundaries between countries and enable recruitment of personnel from a bigger geographical area than previously. It is reasonable that this trend will continue.

The trend of an increasing energy consumption per capita provide the two regions with future opportunities as they are important for providing energy.

Challenges

Ethical issues are challenges important to emphasize. The awareness of negative ripple effects from the industry challenge companies present in the respective regions. It requires operating companies to make sure that every procedure in every single operation is executed in a safe manner. Ethical challenges generates something positive in that perspective.

Two other future challenges have been emphasized previously in the study. Limited access to qualified personnel and experienced difficulties in transferring critical information and lessons learned from experienced to inexperienced personnel are important future challenges for operators to consider. Especially since predictions indicate that these challenges will become even more important in the future.

Several social effects were a result of the arabic spring[4]. Ripple effects from the positive wave of demonstration can however be a future challenge as it can reduce energy supply from the Middle East region. An example is how oil supply from Libya was significantly reduced during the riots in 2011 (Webb, 2011).

The Middle East is currently strongly depending on high revenues from the oil and gas industry. In addition, the regional attraction is solely based on the oil and gas industry. A challenge will appear when oil and gas becomes less important.

In addition, there is a significant social difference between the lifestyle of the local community and expert staff that are temporarily located in the region. Many nations also treat national citizens preferential and disregard the immigrants and the importance of their presence and labour. Examples are how in some nations it is only national citizens that have access to Universities and are allowed to own land.

To operate in the NCS region it is demanded that companies create positive domestic ripple effects. This has been important for the Norwegian government and was central

[4]The Arabic Spring refer to the wave of demonstrations and protests occurring in the Arab world. It began in December 2010 and have forced rulers from power in many countries in the Arab world, e.g., Tunisia, Egypt, Libya, and Yemen. Civil uprisings have erupted in Bahrain and Syria, while major protests have been held in Algeria, Jordan, Oman, Kuwait and Morocco (Kabir, 2011)

in the ten oil commandments that shaped the NCS (Table 6.2). Even though the ripple effects from such an initiative are positive it can act as a barrier for operating companies looking to start business in the region.

7.6.4 T - Technology

Opportunities

Future technology opportunities can potentially have significant positive effects in the two energy regions. Development of drilling techniques able reach previously unavailable reservoirs can increase the global recovery factor significantly. Development in extended reach drilling (ERD) techniques can enable land based development of reservoirs that previously required operations offshore. Examples of development in technology that can increase the global recovery factor significantly are numerous, e.g:

- Seismic technology to help discover new reservoirs
- Chemical treatment to reduce residual oil saturation
- Subsea separation techniques enabling production at lower reservoir pressure
- Drilling methods to reduce drilling costs offshore
- Technology development that makes integrated operations more efficient and reduce uncertainty in operations

These examples represent several future opportunities for the two regions.

The strong technology drive on the NCS and how the region has been a source of technology and innovation worldwide will provide future opportunities for the region. The region is used to face new challenges and the industry in the region has developed a can-do attitude.

Challenges

Both of the regions face the indirect challenge of future technology development making hydrocarbons redundant or replacing hydrocarbons in markets where hydrocarbons are dominating. This will reduce the price of oil and gas significantly. However, it is important to emphasize that the current global energy consumption is not sustainable and that research to develop new sustainable energy sources is important and extremely positive.

Technology development will increase recovery from old assets and new fields being into existing facilities will elongate the lifetime of existing installations in the Middle East and in the NCS region. An indirect challenge as a result of this is the need of an increased focus on maintaining integrity of old installations and infrastructure.

The rapid development of technology has led to a shift in knowledge location in the industry. Previously, the location of knowledge and competence was in operating companies, with episodes of support from service companies. It is clear that it currently is the service companies that has the most in depth knowledge about their products and services. These companies now do a significant amount of the work with drilling and completing wells and do most of the research and development, i.e., their knowledge is very important and early implementation of service companies should be emphasized. It is unfortunate that some operators refuse to acknowledge the importance of service companies and therefore ignore much knowledge available. This can result in missed opportunities of improvement. The development in technology will continue and a future challenge for operating companies will be to incorporate service companies effectively in the planning phase.

A future challenge for the Middle East is how the region depend on development in oil and gas technology. The region is expected to experience an increase in demand for IOR and EOR technologies, new drilling technology and completion concepts. Easy accessible resources will eventually become empty, forcing the region to develop more complex, smaller and deeper reservoirs. New resources are believed to include:

- Deeper fields with high pressures and temperatures
- Heavy oil
- Gas resources with a high H_2S content, i.e., sour gas

The region has to focus on developing gas capacity to meet the increasing demand from future energy generations. The region will also have to tackle difficulties in accessing new technology because of the region is in general less attracting supply companies and a the global demand for the technology is high. In addition, the region has few local innovators and leading supply companies.

7.6.5 E - Environment

Opportunities

The increasing public perception of the importance of providing energy to the global community can be considered an opportunity for the two regions.

Some opportunities in the NCS region are a result of a decrease in global temperature. Areas previously considered unavailable because of huge amounts of ice are now more relevant for the E&P industry. The trend predicts that these areas will be more important as time proceeds. However, it is important to highlight the importance of exploration activities in the arctic being executed in safe manners and with great care and consideration for the environment.

The Middle East also has a traditional low focus on HSE activities. However, the HSE focus in the region is currently increasing as companies has constructed objectives to address environmental issues, e.g., mitigating flaring, pollution and increasing water management. The focus on developing gas has also increased because of the region experiencing heavy pollution from using oil and sometimes heavy oil in power production. As aforementioned, the use of gas to produce power is significantly less harmful for the environment. The combination of these positive trends are considered a future opportunity for the Middle East to reduce the regions negative environmental footprint. The Middle East region might benefit to implement lessons learned from the NCS to reduce climate gas emissions from the industry and improve HSE quality.

Challenges

Environmental challenges exist in both regions. As assets in the two regions grow more old an important challenge is to secure the integrity of assets to avoid gas leakage, blow outs and other harmful incidents that might occur. The subject was discussed by Hamdi et al. in 2010. The authors emphasized the importance of maintaining well integrity as wells reach an age where frequency of integrity problems increase.

An increased public focus of environmental harm is a future challenge for the two energy regions. It is important that E&P companies take this challenge seriously and develop methods to decrease outlets of climate gasses and implement carbon capture and storage (CCS) technology.

The Middle East has currently limited gas handling capacity and it is therefore a common practice for operating companies in the region to flare gas. The global climate can benefit from the region using a higher percentage of the produced hydrocarbons and reduce the amount of flaring.This is a future challenge for the region. Building gas pipes, infrastructure and incorporating methods to mitigate gas flaring can benefit the environment, but require large investments.

A challenge for the the future work on HSE and environment in the Middle East is getting rid of how environmental enforcement groups are within control of national oil companies in the region. It is reasonable to believe that quality of work on HSE and environment in the region is significantly reduced as a result.

7.6.6 L - Legal

Opportunities

Legal opportunities are closely related to the political category. In the Middle East future opportunities are present as a result of the current development in remaining oil reserves globally. The NCS region was provided with future opportunities in the form of the delineated agreement with Russia. Legal opportunities might also be a result of the upcoming parliament election in Norway.

Challenges

An unstable legal environment in the Middle East is a challenge that can be connected to the issue of political instability in the region.

Legal factors that might affect both the regions can also be placed in the political and the environment category. The concern of an increase in global temperature because of elevated climate gas emissions during the last decades can result in future laws affecting the two energy regions. A previous example is the Kyoto protocol, which imposed legally binding greenhouse gas emission constraints on industrialized countries (Bøhringer and Vogt, 2003).

A challenge for the Middle East is how national oil companies has monopoly and control the industry in many countries in the region. Another challenge is how some Nations in the region require local content through legislation and have unfriendly rules towards foreign ownership. The combination is an unfriendly environment in disfavor for attracting international expertise and service companies.

7.6.7 Declining Production a Future Challenge for the OME

Throughout history the OME has always had significant amounts of hydrocarbons available onshore, i.e., oil and gas has been easy accessible. A future challenge for the operating company will appear when production rates decline and the onshore resources gets more difficult to extract. As a result, the OME might have to consider moving their operations offshore and strengthen their participation in international operations. This will require changing and enforcing departments, processes and employees. It will require significant amounts of effort and resources and should not be underestimated by the OME. Declining production rates will be a challenge for the ONCS as well. However, the company has much experience for international and offshore operations.

PESTEL Analysis of Future Opportunities and Challenges in the Two Regions Part 1		
Category	The Middle East	The Norwegian Continental Shelf
POLITICS		
Opportunities	• Increased power because of a global shift in remaining resources.	• Stable political environment, clear governance and segregation of duties and a competitive market. • No legislation favor local suppliers or content. • Parliament election in 2013. • Delineation agreement with Russia
Challenges	• Political instability as a result of the Arabic Spring • Volatile political environment and less clarity in regulatory roles. • Frequent monopoly situations. • Legislation favor local suppliers and content. • Close ties between national oil companies and ministry.	• Increased expenses because of regulators demanding electric power from land combined • High tax rate combined with increased fees on CO_2 outlet.
ECONOMICS		
Opportunities	• High demand for oil and gas elevating prices. • Significant cost reduction potential in the E&P industry. • Historical low lifting costs creating significant potential for improvement in the future.	• High demand for oil and gas elevating prices. • Significant cost reduction potential in the E&P industry • Sovereign wealth fund to secure local economy.
Challenges.	• Vulnerable for drop in oil prices • Increasing pension costs. • Low focus on alternative industry and cross industry synergies.	• Vulnerable for drop in oil prices. • Increasing pension costs.

Table 7.4: Summary of the PESTEL analysis of future opportunities and challenges part 1.

PESTEL Analysis of Future Opportunities and Challenges in the Two Regions Part 2.

Category	The Middle East	The Norwegian Continental Shelf
SOCIETY		
Opportunities	• Social media provide recruitment opportunities. • Increasing energy consumption per capita favor the E&P industry indirectly.	• Social media provide recruitment opportunities. • Increasing energy consumption per capita favor the E&P industry indirectly.
Challenges	• Increased awareness of any negative ripple effect from the E&P industry. • Difficulties in recruiting qualified personnel, implementing lessons learned and achieving continuos improvement. • Arabic spring reducing oil supply from the Middle East. • Highly defendant on oil and gas revenues and regional attraction is based on the oil and gas industry. • Highly defendant on foreign work force and competence. • Preferential treatment of national citizens.	• Increased awareness of any negative ripple effect from the E&P industry. • Difficulties in recruiting qualified personnel, implementing lessons learned and achieving continuos improvement. • Requirement for operating companies to produce domestic ripple effects to be allowed to operate on the NCS.
TECHNOLOGY		
Opportunities	• Technological progress making previous unavailable resources available. • Increased focus on increasing local gas capacity.	• Technological progress making previous unavailable resources available. • Offshore technology progress favoring NCS in particular. • Frequent previous challenges have created a can-do attitude. • Technology region that is a source for technology and innovation worldwide.

Table 7.5: Summary of the PESTEL analysis of future opportunities and challenges part 2.

PESTEL Analysis of Future Opportunities and Challenges in the Two Regions Part 3.

Category	The Middle East	The Norwegian Continental Shelf
TECHNOLOGY		
Challenges	• Technology breakthrough creating new form of energy to replace todays use hydrocarbons. • Cooperate with supply companies to access and implement new technology. • Dependent on development in technology to deal with more complex reservoir and reserves. • Few local innovators and leading supply companies.	• Technology breakthrough creating new form of energy to replace todays use hydrocarbons. • Cooperate with supply companies to access and implement new technology.
ENVIRONMENT		
Opportunities	• Increased focus on the importance of providing energy to the global community • Increased awareness of the benefits of using oil and gas instead of coal with regards to CO_2 emissions • Companies increasing focus on HSE provide future opportunities for HSE improvements.	• Increased focus on the importance of providing energy to the global community • Increased awareness of the benefits of using oil and gas instead of coal with regards to CO_2 emissions • Increased opportunities in the arctic because of ice melting
Challenges	• Mature assets provide integrity challenges • Doing business in a world with an increased public awareness of environmental harm because of the climate crisis • Increasing gas handling capacity to reduce gas flaring • Environmental enforcement sometimes controlled by national oil companies	• Mature assets provide integrity challenges • Doing business in a world with an increased public awareness of environmental harm because of the climate crisis • Focus on making operations more environmental friendly and develop methods to reduce CO_2 emissions (CCS)

Table 7.6: Summary of the PESTEL analysis of future opportunities and challenges part 3.

PESTEL Analysis of Future Opportunities and Challenges in the Two Regions Part 4.

Category	The Middle East	The Norwegian Continental Shelf
LEGAL		
Opportunities	• Opportunities because an increasing part of the worlds remaining oil and gas resources is located in the region	• Parliament election in 2013 creating legal opportunities for further activities in the region
		• Delineation agreement with Russia
Challenges	• Volatile political environment creating lack of legal stability	• Implemented laws increasing costs for operating companies
		• High tax rate combined with increased fees on CO_2 outlet
	• Global agreements similar to the Kyoto protocol imposing constraining laws	• Global agreements similar to the Kyoto protocol imposing constraining laws

Table 7.7: Summary of the PESTEL analysis of future opportunities and challenges part 4.

8 Discussion

A successful WDP can increase efficiency of drilling operations and improve the overall quality in the planning, execution and follow up phase. By implementing the aforementioned suggestions the OME can improve communication between departments, secure involvement of key personnel, achieve a more unified way of working and improve the ability to learn from previous operations. Quality assuring and structuring of the WDP has great potential.

However, to verify the quality of the study it is important to discuss the research method and review results of the WDP analysis. This is emphasized in the next two sections.

8.1 Discussion of Research Architecture and Method

It is important to emphasize that the presented study is not without limitations. There are several points that could have increased the quality of the study. Some points are related to the contingency in research resources and others related to the case study research design.

The criticism towards the qualitative case study strategy include concerns of the strategy being too subjective and that there are problems of generalization. Criticism has also been raised towards a lack of transparency and that the studies are hard to replicate (Bryman and Bell, 2007).

The researcher exposes subjectivity to the study several times during a case study. The most prominent areas of subjectivity in this study is during collection of the data and during interpretation of findings. The subjectivity is however reduced when comparing findings from both the operating companies and during discussions with senior personnel at OME and ONCS. This reduces the chance of overlooking similar findings and help the author discover common denominators with regards to existing pain points in the WDP of the operators. The empirical findings has also been discussed with senior personnel at PwC Stavanger to limit the subjectivity of the study.

The aim of the study is, among other things, to suggest a strategy for how to improve the WDP by using business mapping and benchmarking based on analysis of the two WDP's. Conclusions drawn from case studies have been criticized for generalizing situations and applying findings to other situations than the cases being studied (Bryman and Bell, 2007). However, the intention of this study is not to generalize the findings to all other operating companies, but to generate new theory based on the findings as a result of the analysis. This is called analytical generalization (Yin, 2009).

In some cases it is difficult to clearly define the findings of the research and how the researcher arrived at the conclusions of the study. This is a concern related to lack of transparency in qualitative research. The study try to increase the transparency in the result section where the evidence and findings during the case study is presented. The purpose of this is to present the the derivation from the initial hypothesis and research topics to the final conclusions of the study (Yin, 2009).

Difficulties with replication of qualitative case studies is linked to researcher subjectivity as a result of the nature of the unstructured approach. The approach highly depends on the researchers way of applying ideas to answer the hypothesis, making it difficult to construct a true replication of the case study. Another element that is of concern when performing a case study is the lack of boundaries of the phenomena that is investigated. According to Yin (2009) this is one of the most critical uncertainties in case study research. However, the study has a clear definition of the WDP as a mean to reduce this uncertainty.

Limitations of the research presented is also connected to contingent resources and information constraints. It is reasonable to believe that because of these resource constraints the volume of theory and quality of study have been reduced.

The number of topics and details in the WDP analysis is limited due to data constraints and time being an issue. However, it is important to emphasize that a more detailed analysis of the WDP could have been performed if information and details of the WDP at the ONCS had been made available earlier.

The collection of empirical data from the ONCS was difficult due to limited personnel availability at the ONCS combined with time available for performing interviews. A specific example is how a meeting with senior personnel at the ONCS was ended before all relevant subjects were discussed due to a lack of time.

The number of semi-structured interviews should also be considered. To increase the quality of the study the number of interviews at the ONCS should have been similar to the number of interviews at the OME. The type of personnel interviewed at the ONCS could have been more varied. This would have increased the quality of study through more differentiated evidence, thus strengthening the credibility of the conclusion. The interviews of personnel could also have bared a stronger resemblance to the semi-structured interview form that was used when interviewing personnel at the OME.

The study also had to investigate the process at a certain level of detail to be able to compare the two WDP's equally. It should therefore be mentioned that analysis of a more detailed version of the WDP could have been conducted if time and resources contingencies had been removed. Examples of constraints in data collection are limited access to KPI's, process details and personnel.

8.2 Discussion of Results

Harmful Incentives

An element discovered when investigating the WDP of the ONCS is how the operator have had experience with incentives in disfavor of the company. Harmful incentives can be similar to the aforementioned conflict in KPI's between the drilling department and the field development department at the OME.

It is important that the use of harmful incentives in operating companies is avoided as it can reduce regional benefits from oil and gas activities and disfavor operating companies. Some operating companies have established incentives in the form of bonuses for field managers that meet short term production targets. During production some wells will experience inflow problems, broken completion equipment (ICD not working, etc.), unknown troubles or other problems that reduce production rates and need attention in the form of well intervention. However, experience has showed that managers tend to postpone or even neglect well intervention and maintenance work because it conflicts with production goals and might result in lost bonuses.

The worst case scenario is managers shutting down wells because maintenance work is impossible without reducing production from other wells. The negative ripple effects are many and include, but are not limited to:

- Sub-optimal well performance and reduced production rate over a significant period of time.
- Reduced well integrity and increased HSE risk because of postponed or lack of well maintenance.
- Reduced reservoir drainage and a lower recovery rate from fields.
- Wells that could have been saved by immediate or early well maintenance have to be shut down.
- Reduced field lifetime because of overall production rate being too low and unable to create revenue and support operational expenditures.

If the operator is a leading regional actor the result can decrease the overall recovery rate in the region significantly because numerous of wells perform poorly across several fields. It can also increase the frequency of harmful incidents and reduce government income from oil and gas activities. It is important to emphasize that the use of incentives and bonuses should support long term operations that favor the operating company and energy region. Employees at the ONCS stated that the use of bonuses and similar incentives were currently not in use.

Difference in Incentive Perception

It is important to discuss the fact that crews can perceive performance incentives in the form of rewards as unfair. Imagine that a crew is rewarded by management because they performed good according to a specific KPI. This can result in other crews feeling unfairly treated if they believe that they executed operational procedures better in all other areas - except for in the reward providing KPI. It is important to emphasize that incentives that can create a sense of unfairness amongst different crews and departments are avoided.

Another negative effect of KPI's and operating goals that operators should consider is their potentially harmful effect on motivation and team spirit. If an incident occur early in the operation phase and ruin the chance of the team reaching the pre-established KPI and operating goals it can reduce motivation and result in poor performance in the rest of the operation phase. It can also result in the crew blaming the ones responsible for the incident. Another important factor to emphasize is the need of carefully articulating the criteria that lead to incentives or bonuses. This will reduce the chance of conflicts as a result of misunderstandings and different interpretation of what needs to be fulfilled to achieve bonuses or other incentives in the form of rewards.

Process Implementation Problems

Operating companies should be aware of potential downside of implementing too detailed and comprehensive processes that employees must follow. Extremely complicated and large processes can confuse employees and decrease process awareness and ownership.

A problem with processes implemented by third parties such as PwC, Deloitte, McKinsey or Ernst and Young is that they risk being overlooked and rendered invalid due to a lack of process ownership.

Very rigid processes on the other hand is a problem if critical problems occur and processes prevent quick decisions. This can lead to inefficiency and suboptimal performance in the WDP.

Change Complications

It is important that the OME and other operating companies are aware of potential complications of change in an organization. Organizational differences and employees being reluctant to change are critical factors to consider for companies aiming to implement changes that are believed to result in improvement. However, the negative effects can sometimes compromise and delete benefits of applying new methods. Even though the suggestions are based on lessons learned and has been proven successful in other companies the effect of changes are difficult to predict in an exact manner.

Different Department Cultures in the OME

As mentioned in the analysis of the WDP of the OME, the OME differs between development drilling operations and complex drilling operations. The study revealed several differences in the WDP between the ONCS and OME, e.g., the OME focusing less on planning procedures, continuos improvement and evaluation of past operations.

The discrepancy in focus can be a result of the complex drilling segment adapting parts of the WDP, operational procedures and culture from the development drilling segment.

Development drilling perform a large number of drilling operations per year compared to the department that deals with more complex wells. The difference in numbers of wells drilled can vary between a factor four and seven between the two departments, thus creating big differences in time schedules.

Development drilling have less time to plan, perform, evaluate and implement lessons learned. If the WDP, parts of the WDP or the mentality from these operations are transferred it will result in sub-optimal processes causing the aforementioned differences. Difficulties in proper allocation of employees can also explain some of these differences. If the OME spend a significant amount of time distributing resources between the two departments it can lead to a decreased focus on preparation and evaluation of wells as they are designed, drilled and completed continuously.

Difference in Potential

Offshore operations and significantly higher lifting costs result in a larger cost saving potential from reducing drilling time and implementing standardized technology on the NCS.

Especially methods for decreasing time spent drilling and increasing effectivity in subsea equipment deployment will favor the ONCS more than the OME. The most relevant lessons learned from the ONCS for OME is related to processes that can increase efficiency in operations, including technology and methods to decrease time spent drilling, improve planning, implement means to improve incorporation of lessons learned and favor continuos improvement and information transfer.

The technique of batch drilling is therefore not suggested as an improvement to the current WDP of the OME. However, if OME start doing operations offshore emphasis should be put on these to investigate potential benefits.

Effective Allocation of Resources

An issue revealed for the OME is how employees do not follow the established processes and many considered them to be unimportant, i.e., a lack of process ownership and awareness was discovered. To assure process ownership a possible solution is to assign a drilling and well team to every single asset.

However, this will require enormous amounts of qualified personnel and is a poor allocation of resources. In addition, the employees will have to be re-distributed every time an asset enters the decommissioning phase and operations are shut down (depicted in Figure 3.2).

Contrarily, having only one drilling department responsible for all activities can lead to a lack of process ownership and reduce the overall quality of the well delivery process. Advantages include an improved communication environment making it easier to learn from previous experience and facilitate for continuos improvement.

It is important to consider the benefits and negative effects when choosing how to distribute the resources throughout the organization.

Inadequate Use of Process Tools

Improvement suggestions should be addressed and reviewed to fit the operation and organization. It should also be emphasized how an insufficient use of tools that aim to improve the WDP can result in poor results in the execution phase and a decreased quality of the suggested improvements. This was confirmed by de Wardt (2010).

An experienced employee on the ONCS had several experiences with an insufficient use of the existing change management processes during the WDP. A lack of change management lower the quality of the WDP and increase the probability of potentially harmful situations occurring in the execution phase.

An analogous problem was presented by De Wardt (2010) when explaining how risk management was overlooked by one of their clients. Investigations revealed that significant elements of the program had been copied and that the result was that risks manifested themselves during execution phase.

Similar Topics

Findings of this study and aforementioned topics has also been given attention by other authors previously.

Similar challenges in the WDP and benefits of WDP tools was presented by de Wardt (2010). The use of business maps and best practice was highlighted by Peterson et al. (2005) and Evensen and Rasmussen (2011[1,2]). Benefits of standardization in the WDP was highlighted by Steffensen and Karstad (1996), Garrett and Drinkard (2002) and Nischal et al. (2004). The use of benchmarking as a tool to improve the WDP was presented by Clarke and Goodisman in 2000 and Ziff and Baciagalup in 2002.

The subject of insufficient supply of qualified personnel in the oil and gas industry has been given a lot of attention in the media (Houston Business Journal, 2012) (Kaspersen, 2012) (Kaspersen, 2012[2]) (Halvorsen and Ellingsen, 2012). The subject has also been discussed at conferences and in publications (Riemer, 2008) (Deloitte & Touche, 2012).

The change of remaining resources globally was highlighted by Omowumi in 2007.

9 Conclusion

The well delivery process (WDP) is a comprehensive subject that involve many departments in an operating company.

This study has analyzed the WDP of an operating company located in the Middle East and the WDP of an operating company located on the Norwegian Continental Shelf (NCS). Several similar challenges in the WDP of the two operating company were discovered. Main similarities include:

- Critical for both operators to secure continuos improvement and implement lessons learned.
- High number of change orders in the WDP experienced.
- An excessive focus on maintaining rate of production affecting the two operating companies.
- Deviating targets and contradicting KPI's compromising the WDP.
- Scarcity on drilling rigs and qualified personnel is an area of concern for both operating companies.
- Common use of standardized solutions.

A difference in numbers of WDP challenges was expected because of a significant discrepency in lifting costs between the two regions. Findings suggest that the operating company on the NCS has had a stronger focus on making processes and operations efficient, thus reducing number of challenges in the WDP.

Consequently, several challenges in the WDP for the operator in the Middle East were not relevant for the operating company on the NCS. Unique challenges for the operator in the Middle East include:

- A lack of change management processes combined with a high number of change orders increase risk and reduce quality of the WDP .
- A lack of formal decision gates and dynamic planning routines.
- A varying degree of process knowledge and missing process ownership among employees.
- High turnover of experienced personnel combined with insufficient training of inexperienced personnel.

- A minimal focus on lessons learned and continuos improvement in the WDP.
- A varying quality of rig contractor performance.
- An insufficient incorporation of data in KPI's.
- An insufficient focus on HSE.
- A lack of dynamic planning.

Several opportunities to improve the WDP of the operating company in the Middle East were discovered in this study. Suggestions to improve the WDP of the operating company located in the Middle East include:

- Establish cooperation forums between field development and drilling and well department.
- Regular meetings between employees as a tool to increase information transfer.
- Encourage a company environment and culture that values sharing of information
- Dealing with the high number of change orders: Workshops to visualize domino effects of change.
- Dealing with the high number of change orders: Perform benchmark studies to find an appropriate level of change.
- Establish buffers to support a robust organization.
- Revise use of targets and performance indicators.
- Implement a KPI that support cooperation and communication between departments.
- Implement important WDP tools and validate that they are used, e.g., tools to improve process ownership.
- Implement mandatory approval points to make sure processes are followed.

Lessons learned from the operating company located on the Norwegian Continental Shelf include:

- Arrange common lunches and publish newsletters to increase information transfer and highlight important subjects.
- Implement decision gates in the WDP.
- Communicate importance of existing processes and establish rigidity in processes.
- Increase dynamics in plans.

- Implement post activities to improve lessons learned, increase documentation of experiences and facilitate for continous improvement.

The benefit of standardized processes was identified by the Norwegian Ministry of Petroleum and Energy (2011[3]) as important measures for increasing recovery. By implementing the suggested improvements the operator can achieve a more effective standardized well delivery process. It will enable faster development of projects, ensure use of the latest technology, increase efficiency in operations and secure continuos improvement.

To analyze the opportunities and challenges in the two regions as they prepare for the future the study utilized a PESTEL-analysis, i.e., an analysis of political, economic, society, technology, environmental and legal (PESTEL) factors in the two regions. Main findings from the PESTEL analysis include:

- Future opportunities in the Middle East include an increased political influence global as a higher percentage of the worlds remaining oil and gas resources are located in the region.

- Future challenges in the Middle East include a future increase in resource complexity, increased volatility in the political environment and difficulties in attracting the necessary expertise and technology.

- Future opportunities on the Norwegian continental shelf include development of technical solutions that makes drilling more efficient, further development in subsea technology, the upcoming parliament election 2013 making and an opportunities as a result of less ice in the northernmost areas.

- Future challenges on the Norwegian continental shelf include developing a closer cooperation with service companies to improve technology implementation and a high cost level in the region because of expensive offshore operations and legislation from the Norwegian government combined with a high tax rate.

- Common opportunities for the regions include predictions of high oil prices elevating revenues, technological progress making previous unavailable resources available and improved CCS methods that favor the environment. Also included are opportunities from an increased focus on providing energy to the global community. Common challenges include the chance of oil and gas becoming redundant and the regions being highly dependant on sustainable oil and gas prices.

10 Future Work

Suggested future work include further analysis of the WDP, analysis of incentives and performance indicators that affect the WDP and research on methods for improving effectivity and efficiency during drilling and well operations.

Further investigation of the WDP in an increased number of operating companies on the NCS and in the Middle East could help confirm or invalidate the findings in this study. It could also provide further suggestions for improving the WDP as a result of insight in an increased number of WDP's.

It would be interesting to investigate similarities and differences between offshore and onshore operations. Interesting subjects to study include:

- Compare operational procedures offshore and onshore - present similarities and the most critical differences, e.g., HSE, logistics, preparation.
- Compare cycle time between similar wells and analyze differences
- Investigate the possibility of offshore operations benefiting from lessons learned from onshore operations and vice versa

This will be highly relevant for operators preparing for offshore operations in the future.

The use of incentives and performance indicators is common in the E&P industry. It is suggested to study the implications of such incentives and performance indicators and suggest negative and positive implications. Specific suggestions include studying the effect of performance indicators used to improve drilling performance and investigate the negative effects of having an excessive focus on short term production rates, e.g., lack of well maintenance, overlooking necessary workovers and reduced overall recovery rate.

Costs related to offshore drilling combined with a significant increase in the general cost level on the NCS makes the potential of applying effective and efficient drilling techniques and solutions greater than ever. Specific suggestions include:

- Study the concept of batch drilling and investigate suitable top hole drilling vessels.
- Investigate and present the most recent technologies with potential of reducing time spent drilling.

The recovery factor on the NCS is among the highest in the world. It is would be interesting to study recovery rates in different oil and gas regions. The study can invetigate reasons for the high recovery on the NCS and explain reasons for differences in recovery rates between comparable regions.

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11 Appendices: Further Information

11.1 Appendix A: The Current Global Energy Scenario

Today the energy scenario is split. Developed countries have shifted their focus towards lowering the carbon content of their energy mix and domestic energy, whilst many developing countries are struggling to secure energy to meet the most basic of human needs, i.e., reliable and affordable energy to reduce poverty and improve health conditions. Development countries rely on accessible energy to achieve international competitiveness and economic growth.

The effect on health by providing the entire global community with access to modern energy services is predicted to be significant. The change will especially impact those who use biomass to fuel inefficient and polluting stoves. Adoption of clean cooking facilities can reduce majority of deaths caused by indoor air pollution. Modern energy can help improve health through refrigeration, improving quality of food and storing of medicine. It can also provide modern forms of communication to improve education, training and awareness.

Availability of energy primarily depend on developing the existing power grid. According to the New Policies Scenario of the IEA approximately $270 billion USD will be invested to provide access to electricity in the period from 2010 to 2030. This represent an average annual investment rate of $13.5 billion USD and is predicted to provide electricity for around 26 million people per year. In spite of this investment rate, more than 1 billion people will lack access to electricity in 2030. The number of people without access to electricity divided by region is depicted in Figure 11.1. To provide the entire global community with access to electricity the IEA estimate that an additional $370 billion USD has to be invested, increasing the total amount of investment to $640 billion USD.

Basic energy services such as access to electricity and clean cooking facilities are vital for the well being of humanity and critical for economic development. To achieve universal access to modern energy services investments from governments of developing countries and the private sector need to increase significantly. Predictions estimate that the extra sum required is somewhere around $30 billion per year. Even if modern energy services are not provided for the global community within 2030, there are still enormous amounts that need to be invested during the next couple of decades (International Energy Agency, 2011[2]). Ripple effects from improving the quality of project management through business mapping can be more efficient operations and improved allocation of resources. In the E&P industry, the result can be an increased number of projects being carried forward, i.e., it can increase the global recovery factor and help bridge the growing gap between energy consumption and production. Government income from the petroleum sector will increase as well as income for E&P companies in the private sector. The concept of business mapping can also be applied to improve project management and increase efficiency in the private and public sector not affiliated with the E&P industry.

Previous Development of the Global Energy Market

The energy supply and consumption in the global society has changed during the last decades. The total global energy supply doubled throughout a 36 year period - from 6 111 million tonnes of oil equivalent (Mtoe) in 1973 to 12 150 Mtoe in 2009. The global energy consumption grew with 78% in the period from 1973 to 2009. Throughout the same time period the distribution between regions changed as well, with Asia and China gaining market shares on behalf of OECD countries in particular. OECD countries have reduced their total share of global energy supply. The countries share was reduced by 18% throughout the 36 years, from 61.3% in 1973 to 43.3% in 2009. Conversely China and Asia have increased their supply share, growing from 7.0% and 5.6% in 1973 to 18.7% and 12.0% in 2009. Energy consumption in Asia has increased at approximately the same pace as their energy supply (supply share grew by 6.4%, consumption grew by 5.9%). The energy supply in China has on the other hand outpaced the consumption by 2.3%, with energy consumption growing with 9.4% and energy supply with 11.7%. The change in world total primary energy supply and consumption from 1973 to 2009 by region in Mtoe is depicted in Figure 11.2 and 11.3 respectively.

The energy markets today are first and foremost influenced by countries outside the OECD and the biggest part of future growth are expected to come from non-OECD countries. In the period from 2010 to 2035, it is expected that they will account for 90% of the growth in population, 90% of the growth in energy demand and 70% of the increase in economic output. The position as largest energy consumer is expected to be attained by China (International Energy Agency, 2011). The country has since 1973 experienced tremendous growth. Their share of global energy consumption has increased significantly and the trend is predicted to continue (Figure 11.5) (BP, 2012). In their Energy Outlook publication for 2011, the International Energy Agency stated that they expect China to consume 70% more energy than the United States by 2035, even though the energy consumption per capita is predicted to be less than half of the level in the United States. Other countries and regions also are expected to experience rapid growth in energy consumption are India, Indonesia, Brazil and the Middle East. BP (2010) expect that China and India will account for approximately 35% of GDP, energy demand and global population by 2035. Future scenarios therefore depend on whether or not the expected development trends in these two countries occur. Another region of interest is the Middle East. The development with regards to energy intensity in the region has the 1970 increased dramatically. In 1970 the energy intensity in the Middle East was approximately 0.5 times the level of other non-OECD countries. Due to access to cheap energy, the energy intensity has changed dramatically and in 2010 it was 50% higher than the level of other non-OECD countries. The Middle East region is expected to be more than twice as energy intensive as the rest of the non-OECD countries (BP, 2012).

Fossil fuels have played an important role as modern society has developed and oil has been the main contributor with regards to source of consumption from 1973 to 2009 (Figure 11.4). Russia is currently the largest producer of crude oil (including NGL, feedstock additives and other hydrocarbons) with 12.6% of the total world production. Countries next on the list of biggest crude oil producers are Saudi Arabia, United States and Iran with 11.9%, 8.5% and 5.7% of the global crude oil production respectively. Looking at net exporters it is one actor that stands out. Saudi Arabia is, by far, the largest exporter with a surplus of 313 million tonnes. Russia are number two with 247 million tonnes and Iran number three (124 million tonnes) (International Energy Agency, 2011[2]).

Development of the Transport Sector

Demand for energy from the transportation sector in emerging economies will increase as growth in real income is expected to elevate demand for personal transportation and mobility. The increase in demand from densely populated regions, e.g., China and India, will be an important factor determining the growth rate. Between 2010 and 2030 it is predicted that the vehicle density per 1000 people will grow 5.7 percent per year in China and 6.7 percent per year in India, as depicted in Figure 11.6. Vehicles per 1000 people in the United States is expected to decrease until 2030, whilst Germany and Japan is expected to experience a slight increase during the same time period. The total number of cars is expected to increase from approximately 0.85 billion (currently) to 1.7 billion by 2035. Cars are today first and foremost sold in OECD countries - a trend which is predicted to continue for approximately eight years. More than 75% of the growth in car fleet is expected to occur in non-OECD countries (Figure 11.6). The numbers of vehicles in these countries is expected to grow from 340 to 840 million during the next 20 years. Car sales in non-OECD countries are predicted to exceed those in OECD countries by 2020-2025. The manufacturing of cars is predicted shift from OECD to non-OECD countries by 2015. Even though progress is made with regards to developing more fuel-efficient vehicles, it will take time for the technology to gain market share and become economically viable. Progress is also made with regards to fuel economy, with the heavy freight industry in the US and personal vehicle traffic in Europe in particular.

	2009			2030		
	Rural	Urban	Share of population	Rural	Urban	Share of population
Africa	466	121	58%	539	107	42%
Sub-Saharan Africa	*465*	*121*	*69%*	*538*	*107*	*49%*
Developing Asia	595	81	19%	327	49	9%
China	*8*	*0*	*1%*	*0*	*0*	*0%*
India	*268*	*21*	*25%*	*145*	*9*	*10%*
Rest of developing Asia	*319*	*60*	*36%*	*181*	*40*	*16%*
Latin America	26	4	7%	8	2	2%
Middle East	19	2	11%	5	0	2%
Developing countries	1 106	208	25%	879	157	16%
World	**1 109**	**208**	**19%**	**879**	**157**	**12%**

Figure 11.1: Number of people without access to electricity by region according to the New Policies Scenario by the IEA (numbers in million). The share of global population without access to electricity is reduced by 5% from 2009 to 2030 (International Energy Agency, 2011[2]).

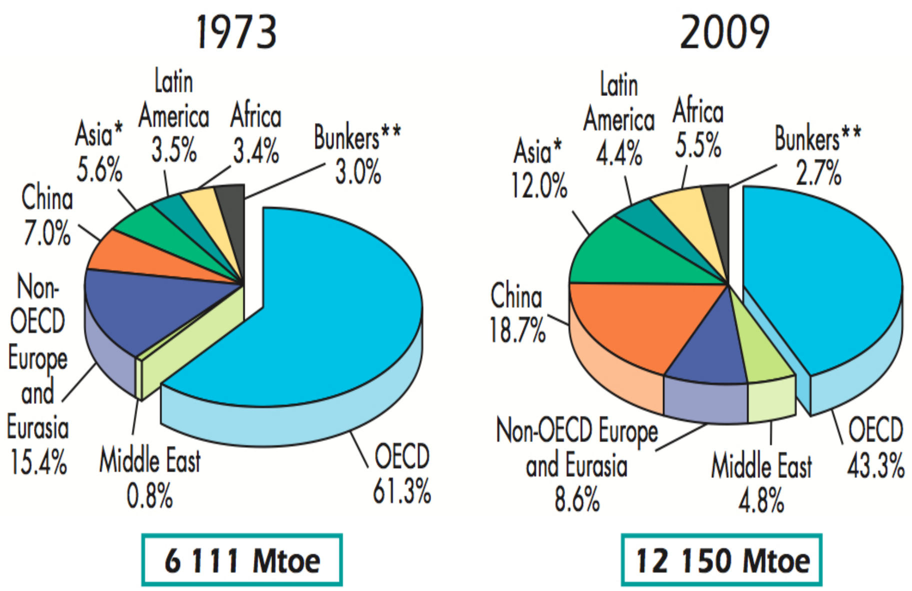

Figure 11.2: 1973 and 2009 regional shares of total global energy supply. *Asia excludes China. **Includes international aviation and international marine bunkers (International Energy Agency, 2011).

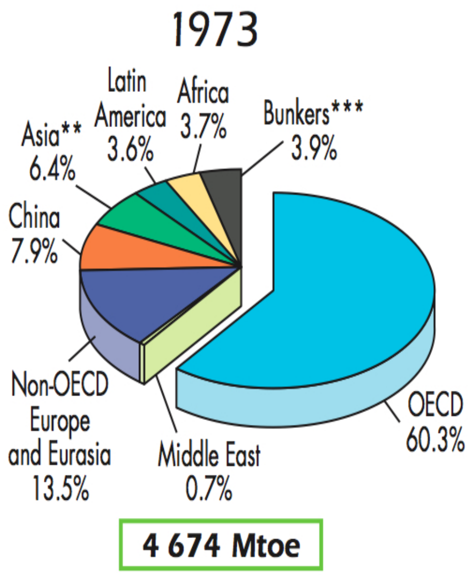

Figure 11.3: 1973 and 2009 regional shares of total global energy consumption. Note that the data prior to 1994 for biofuels and waste final consumption have been estimated. **Asia excludes China.***Includes international aviation and international marine bunkers (International Energy Agency, 2011).

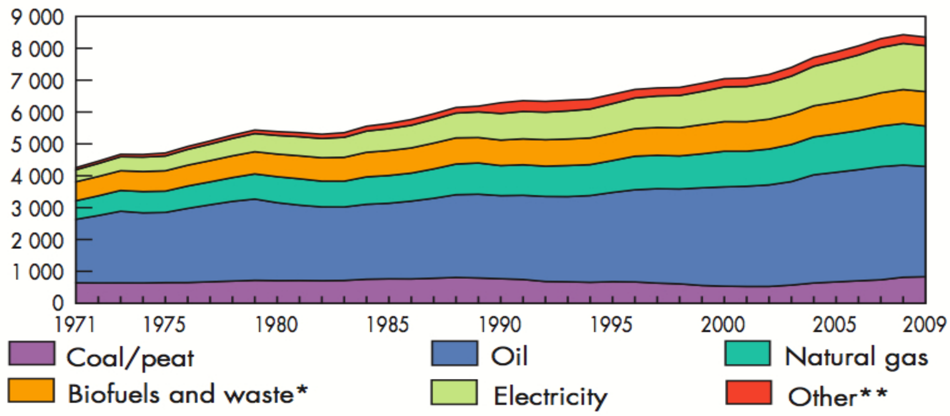

Figure 11.4: Development in world total final consumption divided by fuel from 1973 and 2009 (in million tonnes of oil equivalent).*Data prior to 1994 for biofuels and waste final consumption have been estimated. **Other includes geothermal, solar, wind, heat, etc. (International Energy Agency, 2011).

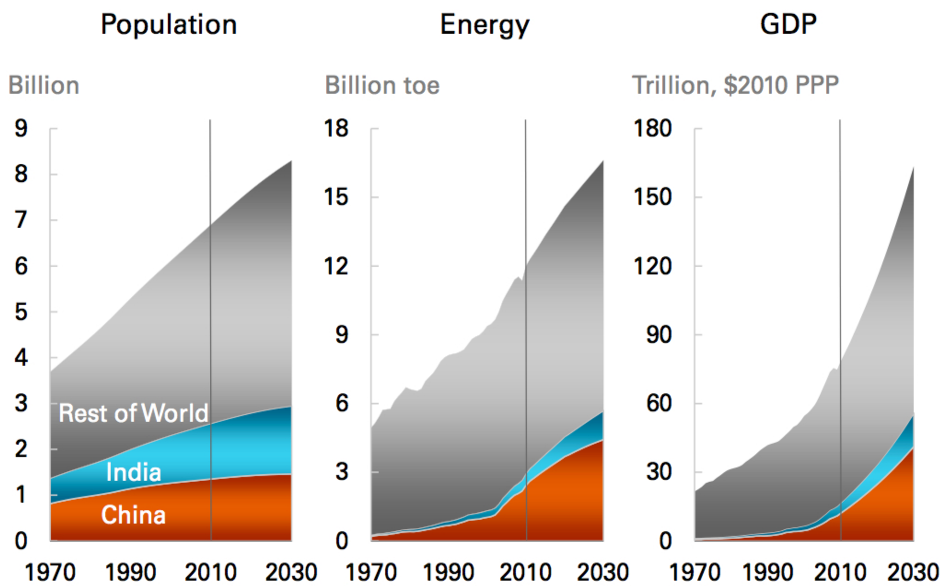

Figure 11.5: Past and predicted growth in population, energy and GDP from 1970 to 2030. Predications suggest that China and India will be the worlds largest and third largest economies and energy consumers by 2030. Together China and India will account for about 35% of global population, GDP and energy demand (BP, 2012).

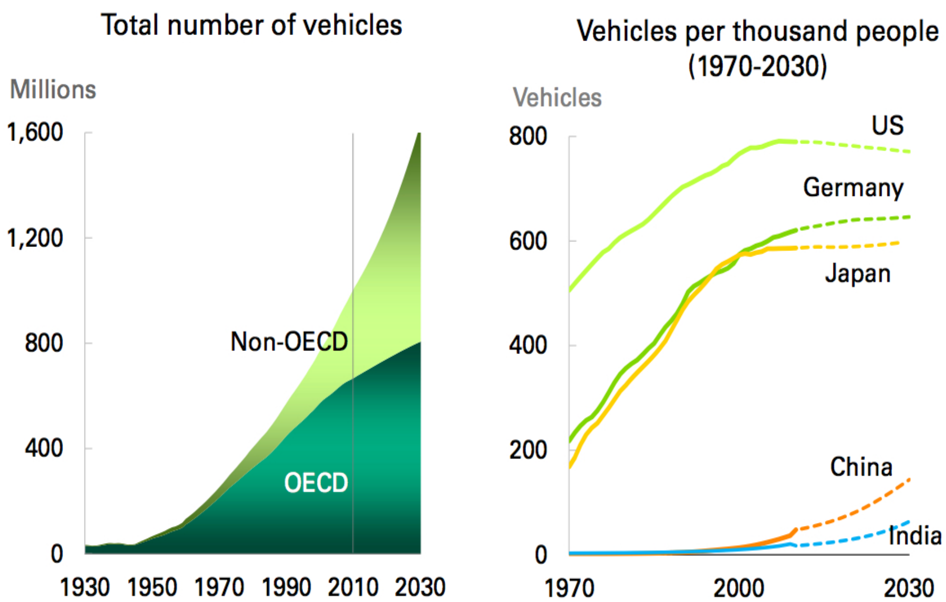

Figure 11.6: Development in number of vehicles globally from 1930 to 2030. The most rapid growth in total number of vehicles and vehicles per thousand people are driven by non-OECD countries, with China and India in particular (BP, 2012).

11.2 Appendix B: Scarcity of Qualified Personnel

The reason for the talent crisis in oil upstream oil and gas was discussed by Samath and Robinson (2005). The negative public perception is brought forward as one of the reasons for the recruitment problems the industry is currently experiencing. Negative media coverage of sever cases of environmental damage, anti-trust practices and allegations of manipulation of the price of fuels have been damaging for the reputation of the industry, e.g., events such as the Exxon Valdez oil spill in Alaska in 1989, the suggested manipulation of fuel prices following hurricanes Katrina and Rita in 2005 and the terrible incident and resulting oil spill in the Gulf of Mexico in 2010. These factors have a negative effect on recruitment as the younger generation (often referred to as generation Y) seem is environmental conscious and value ethics. The high average age in the industry might also explain how parts of generation perceive the oil and gas industry as low-tech and outdated. Another reason mentioned as a possible cause of the recruitment crisis is the instability and cyclicality of the oil and gas industry. The industry is highly dependent on oil and natural gas as a commodities, making the industry vulnerable for changes in price. As the price of oil and gas rises, E&P companies are more than willing to invest in projects and the need for workers increase. Major discoveries, e.g., Havis, Johan Sverdrup and Skrugard on the NCS, also effect the optimism in the industry and often help boost future recruitment (Økland, 2012). Conversely, a sinking oil price as a result of high supply often result in staff layoffs and projects being put on hold. The instability in the oil and gas industry may discourage many potential employees due to a lack of long-term viability. Enrollment in petroleum engineering and geoscience programs is also important recruitment of qualified personnel in the oil and gas industry. It was reported that the number of graduates has dropped by 90% from 1982 to 2006. Proposed reasons for the decline in graduates were perceptions of the industry lacking attractive opportunities at junior levels and little work/life balance. Samath and Robinson (2005) listed six important areas for oil and gas companies to focus on in order to enhance recruitment of young professionals;

1. Career development possibilities within the organization
2. Sense of purpose and decision influence in the work
3. Mentor and guidance availability
4. Work/life flexibility
5. Well functioning and open social networks
6. Access to modern working environments, e.g., online learning tools and online methods for problem solving.

The study by Samath and Robinson (2005) conclude that there is a significant chance of talent shortage and loss of knowledge and know-how within companies in the oil and gas business. The authors highlight the need for companies in the oil and gas industry to evaluate their recruiting process and address the way organizational strategies are communicated, e.g., through branding and reward programs. Companies were also advised to increase the focus on developing and retaining employees.

11.3 Appendix C: A Benchmarking Example

Clarke and Goodisman (2000) introduces ten key steps in benchmarking in the paper *"Utilizing Benchmarking to Add Value to Field Operations*, where costs and methods of oil and gas operations for approximately 2000 fields was examined (Figure 11.7). Included in the study were areas in Western Canada and most of the producing basins in the lower 48 states in the Us - both onshore and offshore. The paper focused on understanding leading practices of successful operators and finding areas for remedial action to increase an operators cash flow.

The initial state in the ten step process is described as confusing. Companies are trying to gain knowledge about their operation and find ways to improve operations. The amount of information is often significant, making it difficult to obtain useful consistencies that can be converted into manageable and useful information. An ordinary problem in this phase is companies overlooking important information, e.g. engineers spending an insufficient amount of time on cost classification as it is considered less important. The process therefore develops into a stage aiming to standardize cost classifications and performance measures, with categories differing in importance from basin to basin. Examples of categories in offshore and onshore operations include well servicing, chemicals, contract service and surface repairs and maintenance.

When standardization and classifications have been dealt with the next step suggested by Clarke and Goodisman (2000) is to determined an appropriate method to compare different sectors, i.e., comparing fields and operations as depicted in Figure 11.8. Once peer groupings are developed performance can be measured and compared. Parameters of importance are operating cost per barrel of oil equivalent (BOE) or per thousand cubic feet of natural gas equivalent (McfE), in addition to watercut, gas-oil-ratio (GOR), field productivity and H_2S content. Figure 11.9 shows operating costs divided by platform categories for a group of 45+ assets in the deeper waters of the Gulf of Mexico presented by Clarke and Goodisman (2000). The platforms within a category were considered peers and consisted of jack ups and compliant towers, floating production systems (FPS) and tension leg platforms (TLP), in addition to sub sea solutions. Different types of platforms are shown in Figure 11.10.

The study showed that operating costs associated with sub-sea facilities are 1.5 to 1.75 times higher than those associated with jacket/compliant and floating/TLP platforms. Processing fees from third parties contributed significantly to sub-sea operating costs and made total operating costs for sub-sea facilities approximately twice as expensive as the two other categories. Even though the gap in costs between categories was well known before the study was conducted it provided an estimate of the size of the gap. Other results presented in the aforementioned paper were distribution details of operating cost components for gas fields in the Gulf of Mexico and the range of operating costs for an old gas asset group nearshore in the Gulf of Mexico. It was revealed that the largest single largest cost component amongst the 375 offshore gas fields is Labour and Field Supervision with Transportation as the second highest cost component (Figure 11.11). Operating costs for the group of nearshore, old, gas fields ranged from approximately US 10 cents per McfE to approximately US 75 per McfE (Figure 11.12).

The study exemplify how benchmarking peers can be used to effectively get an impression of operating costs or other important elements of importance for operating companies. This include benchmarking change orders percentage in the WDP to get an impression of an appropriate level of change.

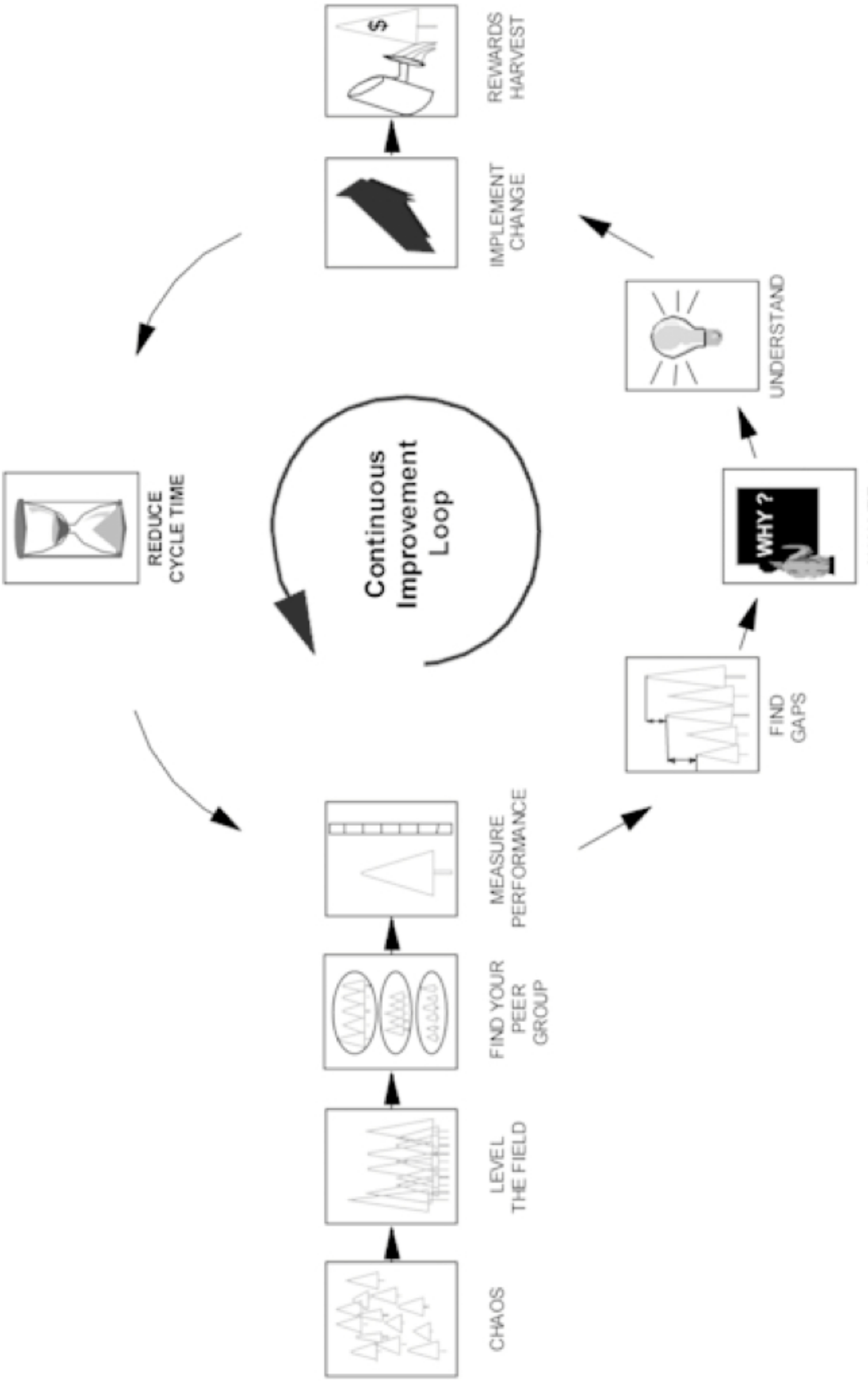

Figure 11.7: The ten step process of benchmarking; from chaos, through analysis, implementation of changes and harvesting of benefits, before ending up in reduced cycle time and creation of a continuos improvement loop (Clarke and Goodisman, 2000).

Product	Distance from Shore	Field Age (since initial development)
Gas	Near	Old
		Mid Period
		Recent
	Medium	Old
		Mid Period
		Recent
	Far	Old
		Mid Period
		Recent
Oil	Near	Old
		Mid Period
	Medium	Recent
		Old
	Far	Mid Period
		Recent

Figure 11.8: It is important to determine an appropriate method to group fields for peer comparison, illustrated here by a peer grouping used for an offshore benchmarking study in the Gulf of Mexico (Clarke and Goodisman, 2000).

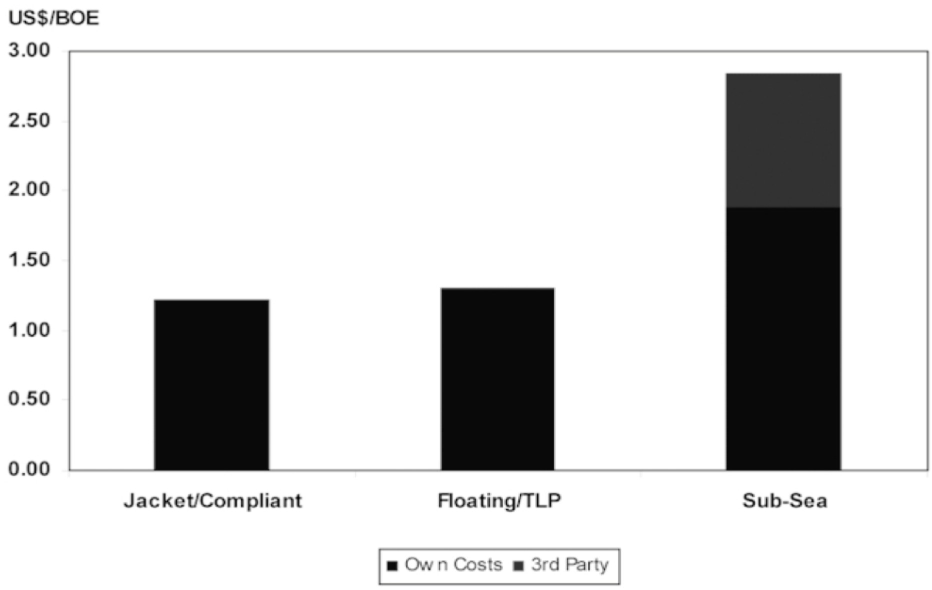

Figure 11.9: Operating costs for a group of 45+ assets in the deeper waters of the Gulf of Mexico. Sub-sea facility costs are 1.5 to 1.75 times higher than those associated with jacket/compliant and floating/TLP platforms. Processing fees from third parties contributed significantly to sub-sea operating costs, making total operating costs for sub-sea facilities approximately twice as expensive than the two other categories (Clarke and Goodisman, 2000).

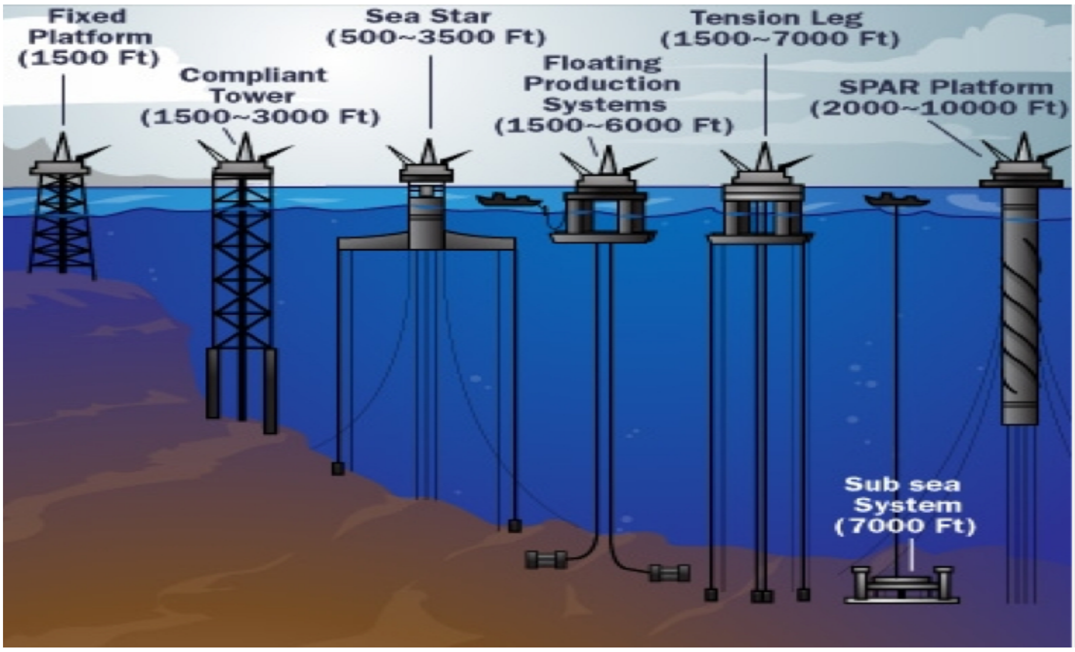

Figure 11.10: Offshore drilling platforms. Ranging from fixed legged platform at depths of approximately 450 meters and less, to SPAR platforms at depths of approximately 610 to 3050 meters (Lamb, 2011).

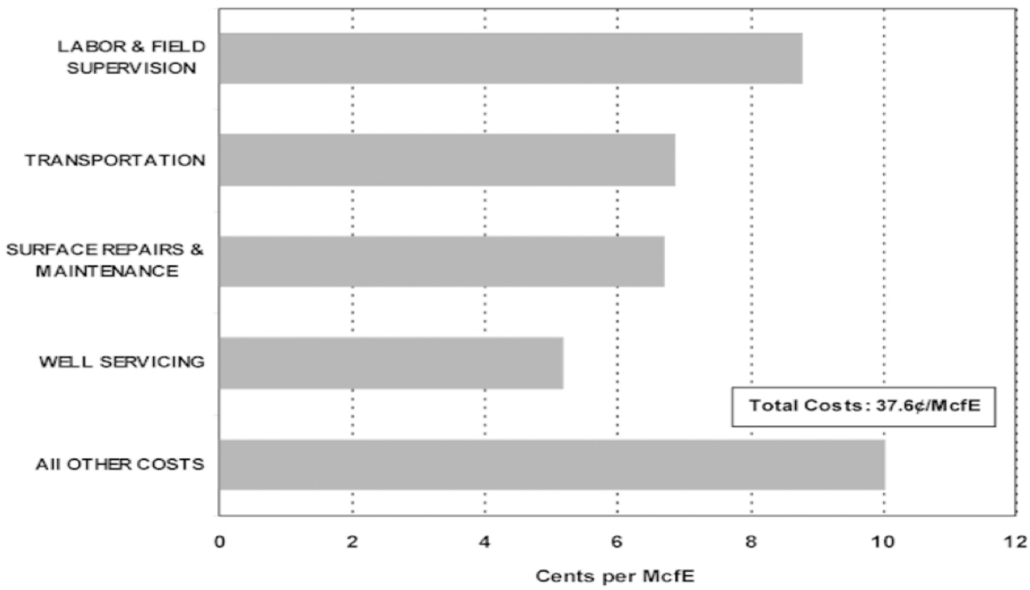

Figure 11.11: The Figure shows how average operating cost components for 375 offshore gas fields in the Gulf of Mexico are divided. The largest single cost component for Shelf offshore operations is Labour and Field Supervision (Clarke and Goodisman, 2000).

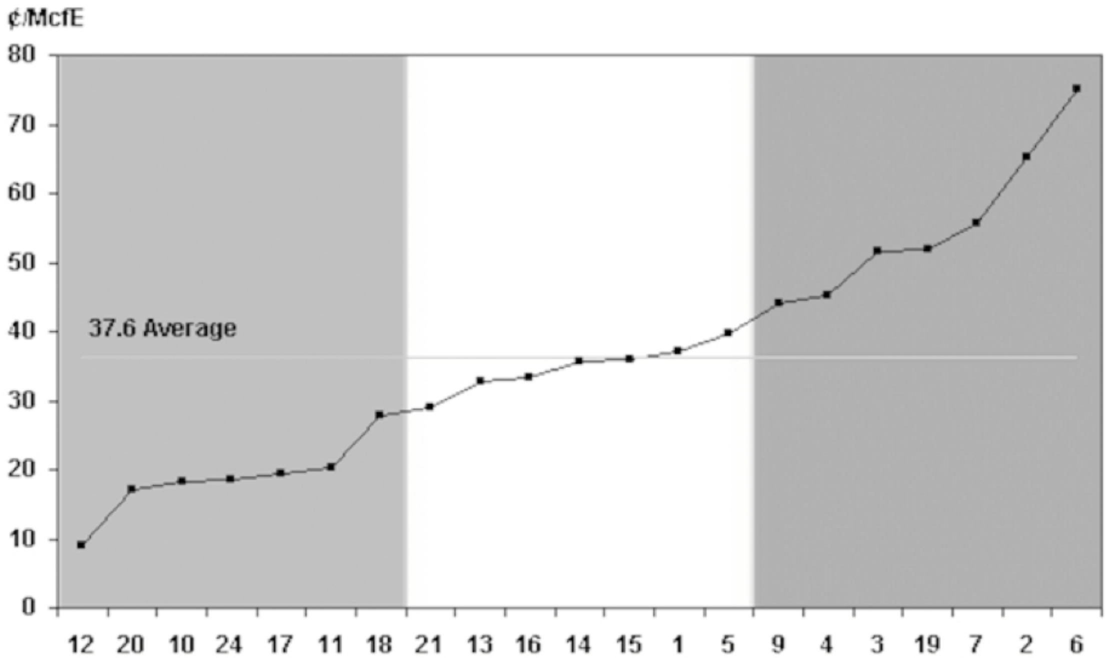

Figure 11.12: The Figure shows a range of operating costs for the nearshore old, gas assets in the group of 375 offshore fields in the Gulf of Mexico. Costs range from US 10 cents per McfE. Fields are marked by a confidential code to protect the clients anonymity (Clarke and Goodisman, 2000).

11.4 Appendix D: Business Models

Operations in Different Regions

The E&P industry in different regions share numbers of common challenges and opportunities even though the geological features can be widely different. The potential benefits of lessons learned in other regions are therefore significant - especially if a company is entering a new one. An E&P company entering a new region will have to adapt to national rules and legislation and face competitors. The management team will also have to construct a portfolio to adapt to the new region.

The E&P business has a global footprint and is present in every part of the world. The working language is english, but governmental requirements towards local content often lead to operations requiring local language consideration and related challenges. Meeting the demand for local content is challenging for many companies in new energy regions and the topic is given more and more attention. An example is how a paper published Bonnel in 2011 address the topic of local presence in Brazil. Managing a culturally diversified team is challenging and has to take a lot of factors into account. The organizational strategy has to be maintained and will require an aligned organization. This includes alignment of management systems and training. Information support and behavioral guidelines and incentives must also be considered. A local strategy will have to meet headquarter expectation and clarify the internal agenda and direction. The strategy also has to consider growth opportunities and necessary measures to attract local resources and competence. A key to success is to have a local presence as well maintaining global appearance. International opportunities are considered positive, but to appear attractive locally it is also important to display local visions. Large international E&P companies often have existing legal-, process- and working frameworks. Entering a new region will challenge this aspect of a company as well; the new organization will have to follow rigid corporate practices and at the same be allowed to adapt to the new region (Evensen and Rasmussen, 2011[2]).

Understanding the framework in which the company has to develop within is important in order to construct a proper strategy and decide opportunities to pursue. There are a lot of factors to consider, e.g. local capabilities and competence, regional environment, operational conditions and regulatory requirements. The corporate culture, systems and processes are often transferred when an organization enters a new region. Emphasis must be put on developing and adapting the organizations according to the local environment. Identifying the key activities and goals of the organization is of importance in order to clarify why the organization is present in the region and what it is doing there. It would also benefit an organization if roles and responsibilities are clearly communicated. As a result of these clarification the organization can develop operational blueprints[1] supporting critical elements of an organization (Figure 11.13) (Evensen and Rasmussen, 2011[2]).

Challenges in new regions can be both predictable and surprising. An example is how

[1]The term ”blueprint” depicts how an organization and its operations co-exist as a coherent system to achieve operational effectiveness and efficiency.

managers and other key experts in an organization will be busy. Entering a new region implies significant amount of work, e.g. preparing operations, license applications, development planning. Previous experience from the NCS have proven E&P blueprinting as an effective way of approaching project in order to construct, develop and implement new processes and operations. To secure implementation of critical elements key personnel are gathered to participate in workshop discussions. These workshops use predefined blueprints as a starting point and help employees visualize the existing or future activities of an organization or department. Working with a default project method within a given amount of time increase the probability of getting full attention from the attending participants, resulting in maximum progress, interaction and input from key employees.

Previous experience by Evensen and Rasmussen (2011) show that there often exist a discrepancy between how employees view their role in the company and the impression received from management systems. Workshops that aim to visualize existing activities have created insight and facilitated important discussion of critical elements in the organization or department. Topics that have been discussed range from quality of the existing management system and how to best update it to how the company should implement learning in the organization.

A proposed reason for the aforementioned gap between employees and management systems is related to recruitment of employees. Previous legacies and way of doing things are often carried forward when a new employee starts working in a new company. The result can be misconceptions and lack of shared views between individuals in the company. Workshops can create a common understanding of key elements in an organization or organization, i.e. consensus between important employees in the way of solving tasks and how the company should perform.

After having created a consensus on present issues the focus is shifted towards future discussions and activities. The discussions will be based on the "as-is"-blueprints that describe the current status and aim to future "to-be"-goals. They will also map activities needed to reach future goals in addition to identification of employees best suited perform them. Workshops will reveal if there is a gap between current and future activities. If a gap exist it can serve as a roadmap for developing and preparing the organization or department for future activities and new responsibilities. The gap will also help employees determine the optimal way of structuring the required capabilities and roles in the organization or department.

Organizations might find it challenging to apply corporate strategies when entering a new region and the existing organizational chart might be unfit with regards to size and focus. There exist a significant potential in reviewing these factors before settling the organizational design. Blueprints can help ensure local ownership and construct a taylor made organizational chart to meet local demands and opportunities. An example of an activity blueprint is depicted in Figure 11.14. A local subsidiary blueprint have the potential of challenging the existing organizational design and processes. However, this will require willingness and constructive communication with the top management.

An important task when entering a new region is to analyze the local environment and critical interfaces, i.e. local government and authorities, license partners and suppliers.

Mutual communication with these interfaces in addition to a dialogue with head office is necessary to secure efficient and predicable cooperation. This will secure clarity and help create a correct image of ownership of activities across external and internal interfaces. It will also give information on regulatory expectations, facilitate discussion and increase the possibility of identifying areas of improvement.

Operators on the NCS have emphasized improved collaboration as well as maintaining a clear understanding of roles and accountability. This have resulted in common repositories of licence information, sharing of geological and geophysical information in addition to environmental reporting. It is also important to be aware of implications of unclear and diffuse understanding of roles, accountability and activities between operating organizations and suppliers. Operators have chosen to in-source operations previously out-sourced as a result of unsatisfactory audits by authorities on the NCS. This is suboptimal and may have been avoided if the aforementioned unclarity had not existed. The cost of organizational redesign and disturbance is high and the reputation and common conception of an organization might change for the worse.

Identifying areas of improvement is important for the development of an organization. Analyzing internal and external activity networks and construction of organization maps provide the opportunity of identifying opportunities, e.g. automation opportunities, technology support, lean operations. The blueprinting approach provides a holistic overview of roles and activities. This makes it easier to investigate relevant improvement alternatives such as simplification or automation.

Discrepancies often occur when trying to clarify how activities actually are carried out and comparing them to what is communicated in the existing management system. Gaps like these are however expected in a learning organization. A high quality management system should describe the optimal procedures for carrying out activities. It should also contain explanatory information. This require processes that keep the management system up to date as well as processes for continuos improvement. An optimal system should avoid expressing activities as isolated sequences along an activity chain and focus on communicating their importance as part of a bigger picture. Every role participating in activities should also be included. Key elements are often overlooked if an activity is kept in a silo and vital roles such as the ones accountable, consulted and informed are often missed. The blueprinting procedure focus on communication to avoid activity silos and aim to capture re-useable approaches and adaptable best practices.

An Example of How to Develop a Business Model

Business Model Phases

As Figure 11.15 clearly demonstrate, the possibility and potential of using the business model approach is significantly larger in early phases of development and before development start. The project boundaries are more rigid after decision gates are passed and final deliveries approaches, while sunk cost and risk increase. Figure 11.15 also illustrate natural phases of a business model approach. Before introducing the concept of operational blueprints, a readiness assessment often referred to as "phase 0" can be performed. This phase can be introduced at any time and its purpose is to analyze the current environment, map capabilities and recognize possibilities. The require a minimum of interaction and will not interfere with the organization and its work processes. The final outcome of this "phase 0"-assessment will cover an organizational status report and assess how the current status reflects ambitions and strategies. A similar study and the introduction of operational blueprints are the main building blocks of phase 1 and is directed at companies in an early stage of developing departments or exploration operators. Phase 1 can help unify strategies together with activities and roles of a company. It will however not investigate if there exist any opportunities related to production or development of facilities. The introduction of the next two phases will imply studies of goals, activities and strategies using similar methodologies as the ones described. These studies will reveal areas of potential with regards to facility development and production. Mapping of existing processes in identified areas of potential is an example of how selective improvements can be made in mature organizations. The introduction of operational blueprints can help improve complex processes and help verify that they meet standards and regulations set by the company or government. Visualization of unstructured data sources in information maps, analyzing corporate performance and risk management are some examples of areas where selective improvements might be applicable.

Alignment and Execution

Evensen and Rasmussen (2011) describe how it is possible to make a business model which fit the blueprint description by a buildup of different activities and workshops. The work effort and focus changes as the process proceed and company representatives should ideally be chosen on the background of their insight and role in selected areas. A project manager should be selected by the company and will be assigned to the entire project at all times. A core team should also be selected for the process. Several disciplines should be represented, e.g. an operation manager, a discipline engineer and IT representatives. Additional resources that might be included in such a process include control room, finance HR and coordinators.

The process suggested by Evensen and Rasmussen (2011) consist of six steps (Figure 11.16). The process aim to secure involvement of key employees, managers and business line managers. An important aspect of the suggested methodology is to identify and prevent existence of departments only communicating inwards and vertically, lacking horizontal communication with other peer groups[2]. This is a potential problem as many different disciplines co-exist in an E&P company and several processes require an effective horizontal flow of information for an optimal outcome, e.g. drilling a new well and how geologists, drilling engineers and reservoir engineers cooperate.

The first three steps to develop a operational business model consist of linking departments and processes in the organization together vertically and horizontally. This information model is used to study relations within the organization and map how its

[2]Departments failing to communicate with other peers in an organization is often referred to as information "silos"

strategies and goals are linked together with activities, flow of information, system support and roles.

After competencies and roles have been studied through the first three steps, areas of responsibility and accountability for key personnel together with the required competence to perform vital activities and activity networks are made evident. The analysis and business alignment is required to develop a taylor made business models, which is realized through the last three steps.

Assessing the Operation Strategy and Mapping Activities, Roles and Information

The main goal in the first step is to develop the operation strategy for the asset. Key elements to capture and visualize are core business, organizational structure together and required competence. The company philosophy and strategies, existing constraints and governing documents are used to form the operation strategy. At the end a clarified set of roles, reporting lines and competencies are mapped as a part of the strategy.

The next step is to move from the operational strategy to the development of specified operational goals and objectives. Through workshops with business line managers the operation strategy developed in step one is now transformed into clearly defined business goals broken into understandable and documented objectives per business line.

The third step consist of workshops with key employees to clarify and analyze activities most vital to achieve goals, sub-goals and objectives developed in the operational strategy. An important aspect of this step is to identify bottleneck activities and activities of less importance. The map will also clarify key roles and their area of responsibility, area of importance and competence needed to perform operational activities, visualized in Figure 11.17.

Opportunities, Work Processes and Implementation

The fourth step will help secure the horizontal and vertical alignment needed to support lean work process designs and facilitate for favorable collaboration across business lines and disciplines. By conducting further analysis of work done in step one, two and three, lean operational opportunities are discovered more easy, potentially enabling assets to reach their operating potential. Aligning interdependent processes will bring lean operational opportunities together. Consistencies in- and between activities, goals and strategies will result in a competitive and operational advantage which is an example of a first level alignment. An example of a second level alignment is when activities are reinforcing each other, for example through activity networks. Third level alignment optimizes work flow through the coordination of information exchange across disciplines and activities. This will result in a decreased level of redundancy and wasted effort and encourage multidisciplinary collaboration.

This method of business presented here has so far focused on revealing and documenting potential processes that can be optimized to support lean operations. After activities have been implemented in the management system, they should also be developed into new work processes developed to work across disciplines within the E&P organization, i.e. both between operators and its clients as well as offshore and onshore. The result might bring significant changes to previous working processes, which are often fit to characterize as "information silos" lacking interdisciplinary work and communication. It is important to emphasize how to integrate the different activities into an operational network to support operational goals and ambitions. Operators and partners have the obligation to see that operations and processes are executed according to regulations and instructions decided by the Petroleum Safety Authority Norway. It is therefore of paramount importance that new work processes are implemented accordingly. The flow of relevant information has to be available to support the decision makers when needed, and alignment of activities and roles have to ensure collaboration and availability of information.

Step six result in specifications and suggested implementation of solutions to support the operation strategy. The suggestions are based on previous analysis of activities and can result in specific suggestions of data storage, applications and portals. The outcome might be specific examples of an architecture developed to support lean business operations, supported by an IT structure and an implementation plan to facilitate operational plans and objectives. Development of collaborations centers and visualizations tools can provide insight and encourage interdisciplinary communication as well as communication between companies and geographic area.

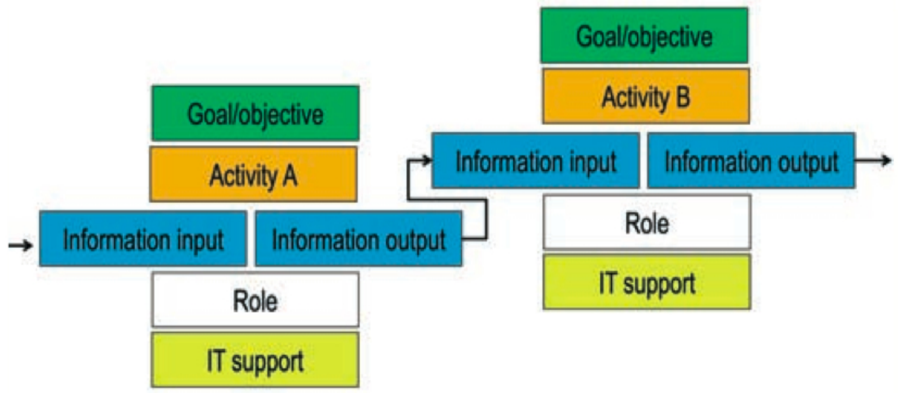

Figure 11.13: Critical goals and objective are clarified to develop a fit for purpose operational blueprint(Evensen and Rasmussen, 2011[2]).

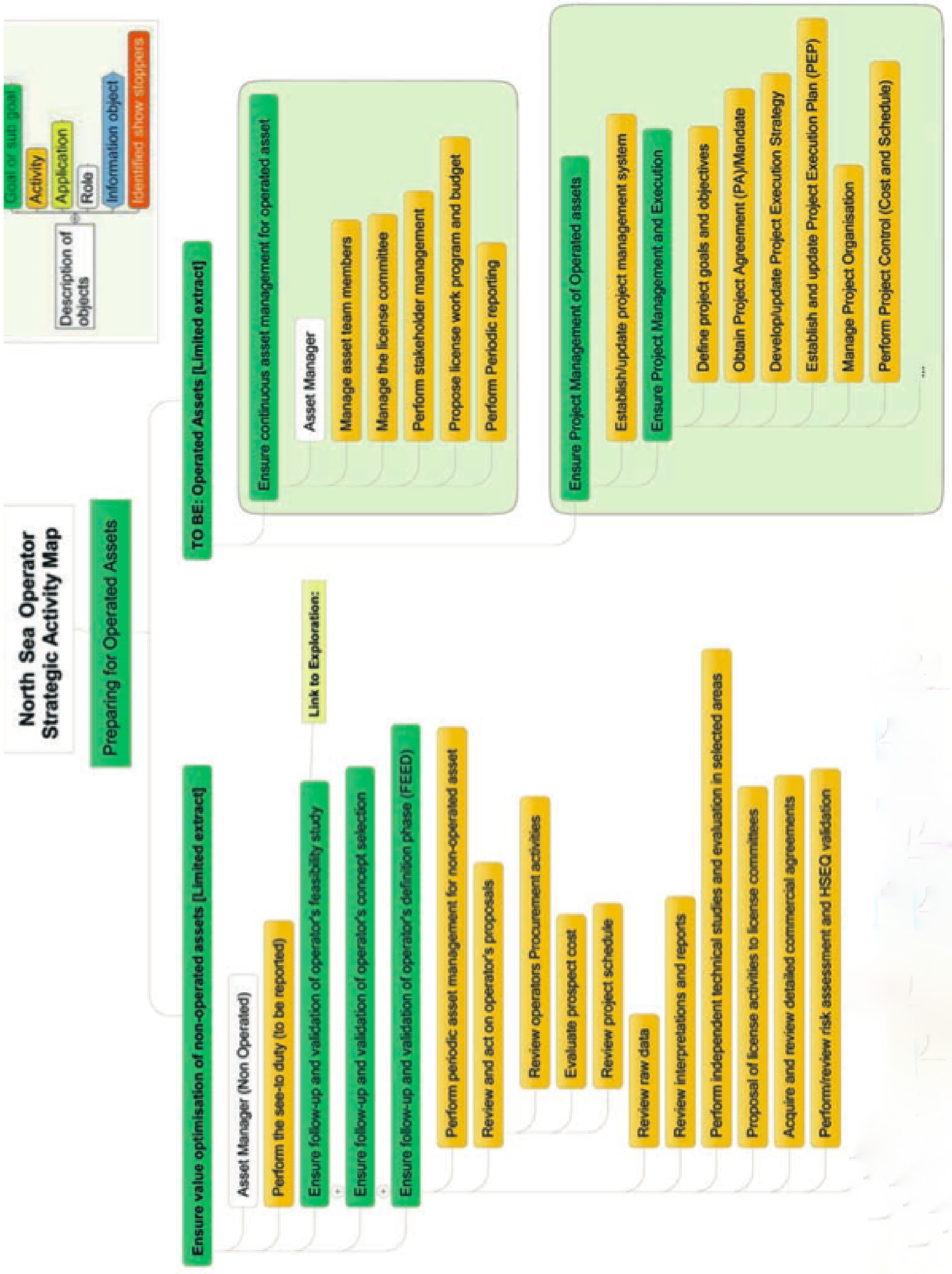

Figure 11.14: Extract of a blueprint of activities which the Asset Manager is responsible for in operated and non-operated assets (Evensen and Rasmussen, 2011[2]).

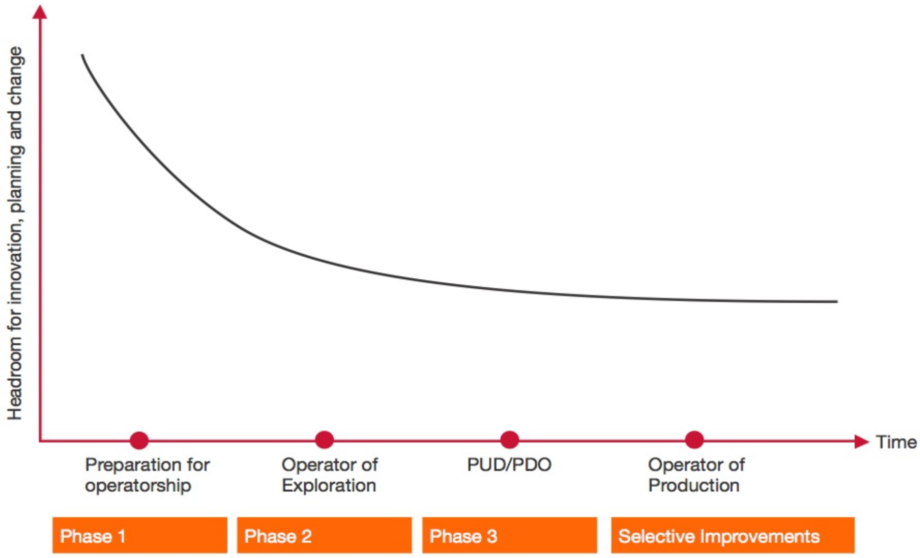

Figure 11.15: The headroom for innovation, planning and change diminishes as time goes by and reaches a constant rate approximately as phase 3 is ended and only selective improvements can be made (Evensen and Rasmussen, 2011[1]).

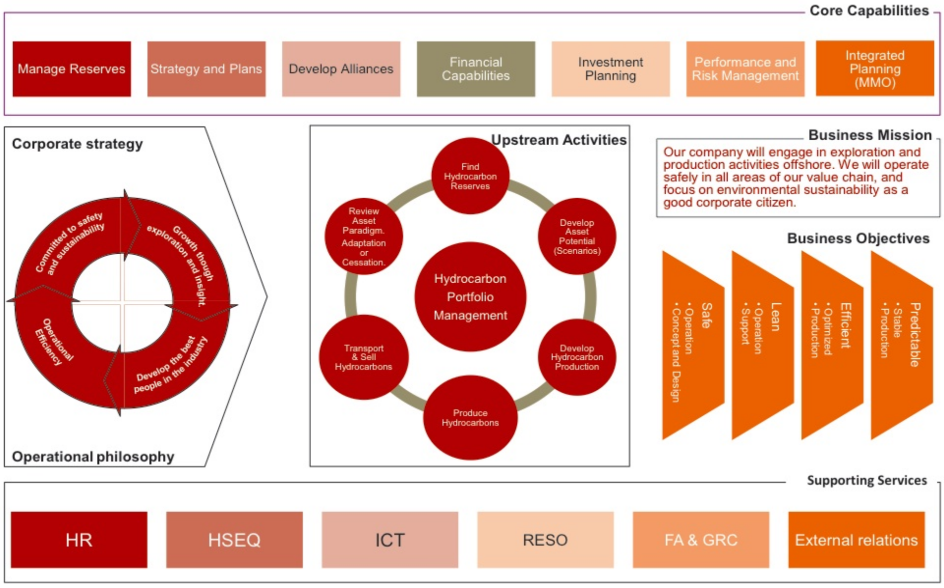

Figure 11.16: E&P Enterprise Model help managers and employees to understand mutual dependencies (Evensen and Rasmussen, 2011[1]).

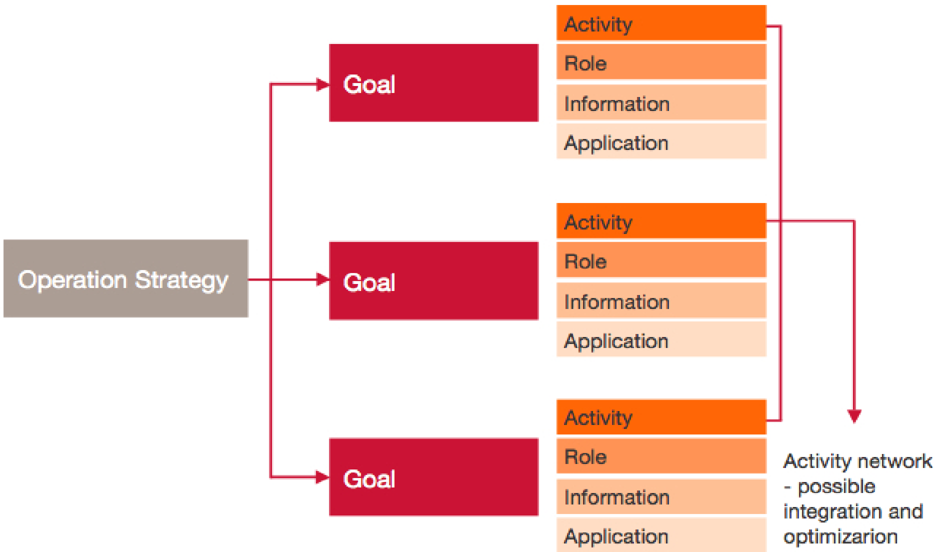

Figure 11.17: Operation strategy, goals and activities mapped, visualizing key aspects needed to reach operational goals (Evensen and Rasmussen, 2011[1]).

11.5 Appendix E: Performance Indicators

Indicators are often divided according to what they report on and at what time the objective of interest has occurred. Indicators like financial revenue in the third quartile, wells drilled versus wells planned or last years HSE incidents are examples of lagging indicators (lagging KPI's), i.e., reports on past events. Lagging indicators are most common as they are often better recorded and more easy to compared to the other category, which is leading indicators (leading KPI's). Another reason for the extensive use of lagging KPI's is that reporting of leading KPI's often require special insight and information about ongoing operations. Leading key performance indicators are often an important element when using improvement techniques to acquire lean[3] operations and effective organizations.

Many of the KPI's that were chosen by Shell are directly linked to value of the company, whilst others are more remote.

KPI categories like "innovation" and "customer satisfaction" are parameters that are directly linked to the value of a company like Shell. Innovation is probably correlated with financial returns, e.g., the bottom line [4] of a company. Customer satisfaction is most likely a leading indicator of market share. Other KPI's can seem distant from measures of interest, such as the KPI "Staff Feelings on How the Company Respect Them" under the "Governance and Values" category. However, it is likely that this indicator is linked indirectly to productivity through important employee related factors, e.g., motivation. Another couple of key performance indicators that is well suited to reflect sustainable development, but might seem distant with regards to value is the KPI's "Staff Believe That Business Principles Protect Them and Encourage Them to Act With Integrity" and "Human Rights". Categories like these are well suited to detect cases of bribery and security measures at work sites around the world. Feedback from these categories might cause Shell to adjust the risk profile of the company - an area that has direct implications for the company (Eccles et al., 2001). Sustainable development appears within a broader model made to create value for stakeholders and wealth for society. The sustainable development business model that Shell use is located within a business model that builds on four important key business imperatives, i.e., reducing cost, create options, gain customers and reduce risk.

Key Performance Indicators are widely used at a variety of levels in E&P operating companies. Example of high level indicators are:

- Average variation in project cost
- Days to target date per 10 000 feet drilled
- Serious injuries per year

[3]The lean philosophy is build on removing resources that does not create value for customer.s The philosophy is build on the preservation of value with the least amount of work possible.

[4]The bottom line is a term referring to a line in the financial statement showing the net result, i.e., income or loss

- Human Resource Efficiency
- Year on year action plan variability
- Percent change in budgeted wells per year

Indicators at lower levels are more often related to specific operations and often updated more frequently. Eccles et al. (2001) emphasize the importance of focusing on performance indicators that capture value, i.e., to identify those measures that really matter and encapsulate as much relevant information as possible. The objective is not to make the list of KPI's as long as possible. This was also highlighted in by Oag and Williams (2000), where the issue of linking drilling performance to complexity and difficulty instead of days per feet between complex and unique wells with different well trajectories.

11.6 Appendix F: The Well Delivery Process

The following sections are based on the paper "Well Delivery Process: A Proven Method to Improve Value and Performance While Reducing Costs" by de Wardt (2010). Other references used are stated in the text.

11.6.1 Well Types and Process Differences

There are first and foremost two factors that decides the level of detail in a WDP. Type of well; the transition from exploration toward development wells will result in a transition from a highly detailed full cycle process to a more repetitive type of process. Uncertainty; technology progress and development result in sub surface models and tools of higher quality. The implication being reduced uncertainty and an increased chance of using standardized design solutions. If an organization use an unfit management method to manage different types of business modes it can result in poor performance. Operations in drilling activities change and it is therefore important to emphasize how different business modes are managed. Understanding the difference, transition and boundaries between the project mode and the ongoing business mode is according to de Wardt (2010) important and critical for success.

A project can be defined as a set of non-repetitive activities aiming to achieve a unique goal within a defined timeframe. The project mode can be complicated and require an enormous amount of resources or it can be small and fairly simple. Exploratory drilling is a project mode example which has a high degree of uncertainty related to it. The well results have to meet a number of pre-defined goals which determines if further drilling activities will take place.

The ongoing business mode is defined as a repeatable process aiming to deliver products and services. De Wardt (2010) describe four basic types of processing that fit the description of an ongoing business mode, ranging from the low volume job shop process to the continuos process phase where a high volume of standardized products or services are dealt with.

1. Job Shop Processing: Characterized by small numbers of unique products and/or services are needed, exemplified by wells drilled in a known area where different locations and specifications are involved.

2. Batch Processing: The volume is moderate, as is the range of products and/or services delivered. Examples are repetition of well sections in a sequence or batch drilling of wells in a well known area.

3. Repetitive Processing: High volumes are delivered and services and/or products delivered more standardized. Flexibility only exist in predetermined options. The process is referred to as "Factory Drilling", exemplified by large numbers of similar wells being drilled and completed in an assembly line process.

4. Continuos Processing: High volumes of standardized products and services are delivered. Examples of this type of business mode in drilling and completion does

not exist. Process plants such as refineries or mills are examples of continuos processing.

Figure 11.18 show features of the different types of operations. Operations in a drilling campaign are initially carried out as projects and move towards ongoing operations as activities change to drilling of multiple wells in field development. Operations develops through a fields life cycle. It is initiated by job shop processing and is developing into batch processing as the well specifications are more defined. Operations can move in the other direction as well, e.g. moving from batch processing to job shop if the drilling campaign include a non-standardized well.

Drilling and completion operations aim to deliver predictable results as effective and efficient as possible. Adjusting the planning and execution activities so that the type of process activity is met is therefore of importance. An enormous amount of time and money is wasted if a repetitive operation is treated as a project. Vice versa; applying planning and executable resources of a repetitive operation on a project operation can result in executable failure. To reduce cost and deliver predictable results it is important to be able to change from flexible to standardized operations. The WDP must be related and scaled to match a variety of operation types. Consistent geology and reservoir features enable wells to be repeated, with the ultimate goal of developing so called factory wells.

11.6.2 Common Stages of a Well Delivery

The Well Delivery Process move from a concept stage with several development options towards a specific and fully detailed well program. The program has to be developed relatively to government approval processes and take specific requirements into consideration. Mapping of requirements and critical information is therefore necessary in order to deliver plans likely to be approved on schedule.

Numerous of options are available in the initial phase of a WDP. With key information being gathered as time proceed it is of benefit for the final outcome of the process to keep key design decisions open for as long as possible. A process where key design decisions are held open in parallel and frozen when the decisions are made often require greater effort. The reward can however be great. Compared to a single line process where decisions are taken early without considering their impact on later design and possibilities, an open and parallel process will most likely avoid later regrets due to premature decision making.

The full WDP consist of several stages and commences with a concept phase where investment opportunities are ranked relatively to each other. The WDP ends with a close out and hand over to operations. The paper written by de Wardt (2010) list the following five generic stages in a WDP:

1. Identification and assessment

2. Evaluation and selection

3. Planning and procurement

4. Execution

5. Close out

The detail of the process depend on previous experience - ranging from an in depth process following every step for a completely new project to focusing more on certain critical elements for a standardized repetitive type of well.

It is vital that existing opportunities and possibilities are mapped early. Stage one in a WDP often identify opportunities and assess them. Possible well solutions are evaluated in terms of uncertainty, cost and risk before they are ranked against each other. The initial cost uncertainty is relatively high, ranging from approximately +50% to -30% according to de Wardt (2010). In step two, ranges of uncertainty on cost are narrowed down to about +25% to -15%. At this stage work on the design of the well is initiated. Critical well elements are evaluated, narrowing down options available for well trajectory and casing diameters. Items with long lead time[5] are procured to secure that it does not effect the project schedule negatively.

The initial stages consisting of identification, assessment, evaluation and selection can be undertaken for batches of development wells as the focus is directed to the plan, execute and operating part of the WDP. These steps are often part of a Field Development Plan (FDP) and include several departments.

The fully detailed well planning is commenced in stage three. At this stage the range of uncertainty is narrowed down to a tolerable level by deciding well design features. Many complex elements have to be considered (Figure 11.19). The range of uncertainty is narrowed down to approximately +15% to -10% and activities that provide the necessary equipment and services are initiated. Because exploration activities are uncertain it is accepted that exploration wells have a wider range of uncertainty. The well program is executed in the next step (five) in order to deliver the chosen design. Type of operations vary. Some might require continuos feedback in order to solve tasks which still have a level of uncertainty tied to them. Other operations are more straight forward without the need of reporting. The final step of a WDP consist of handing the well over to the operating organization and evaluating the WDP. It is important that the hand over procedure secure that the operator is fully aware of the operating capability of the well and its exact status. Older wells have provided the operator with undesirable surprises during remedial work because important features of the well not have not been properly mapped and critical well details have not been recorded.

The close out of a well is initiated as documentation, lessons learned and other critical information is handed over to the operating organization. It ends when the well si abandoned.

[5]Lead time is defined as the amount of time elapsed between the start of a process and when it is completed.

11.6.3 The Well Delivery Process - a Value Delivery System

According to de Wardt (2010) a value delivery system (VDS) can be defined as a system that describe how a business deliver value to internal and external customers. It is important that a company has defined how it deliver value to internal and external customers. In drilling and completion the well delivery process (WDP) is a set of activities in order to plan, execute and close out a well. The process defines activities ranging from concept development to delivery of the product to operations and fit the description of a VDS.

Two dipoles in the well planning phase represent extreme differences in work load. An E&P company should avoid spending too much time, funding and competence than required for the type of well and its location - the strength, capacity and size of the organization should also be taken into consideration. If too little resources are tied to a project, the company might experience unforeseen problems and additional risk in the execution face, with failures and dysfunctional wells through its operating life cycle as a consequence. Both of the extremes can result in an unnecessary spending of company funding, work capacity and time.

It is important that the WDP focus on delivering value to the end customer, i.e., communication of customer intentions and goals must be emphasized during the process. Decisions must satisfy end customer values such as time schedule, cost, functionality and specifications. The WDP aim to secure input from critical sources. This implies that individuals with knowledge, information and data pertinent for the planning and decision making must be involved in the process, including departments other than Drilling and Completion, technical consultants and suppliers.

Large international oil companies such as Shell, BP and Total often have pre-defined procedures and practices that dictate how business is run and projects are carried out. Recently formed smaller oil companies that lack this type of framework have to ensure that the WDP define operational processes within every single drilling and completion program. This must be emphasized until practices and procedures are extracted and established as best practice procedures that can be used for future reference.

Oil companies have in recent time defined processes designed to realize values from opportunities that the company is able to access. These are often referred to as capital value and opportunity realization processes. In a large oil company they are normally incorporated in departments, meaning that the existing WDP is designed to fit these processes. However, in the case where well activities are the main part of an organization the WDP also has to take economic evaluation aspects into consideration - a process normally incorporated in the capital value and opportunity realization process.

11.6.4 Additional WDP Tools

Basis of Design and Risk Management

A documented list of facts that serve to demonstrate and implement key information about the well concept is a useful WDP tool. Such a statement is often referred to as the Basis of Design (BOD). This design often covers all disciplines related to the planning and execution of a well and include details of particular relevance, e.g., sub surface model details, existing uncertainties, identification of risks. THe BOD also document important well specifications, such as tubing and casing sizes, and completion requirements. The OD also require a so called Well Proposal Document that contains information about the geology model and important evaluation areas to support the well design.

Another important aspect of the WDP is management of risk and uncertainty - two terms that can be managed in similar ways. While risk is a term often related to situations with only a negative outcome, uncertainty is a term used for situations that have an additional upside. Risk and uncertainty management can be applied in a quantitative way, a qualitative way, or the qualitative and quantitative way can be combined to create synergy effects[6]. The qualitative method often assign a certain grade related to the probability of an incident and its impact. This makes it more easy rank each risk or uncertainty element relative to others to focus on what element to attack first. The quantitative analysis is divided into deterministic and stochastic methods. Stochastic quantitative analysis enable modelling of the probability and impact of outcomes of an operation in terms of cost, schedule and functionality variances. An example of stochastic modelling is Monte Carlo simulations, which provides insight in the projects range of economics and the value of proceeding with a certain project, in addition to the effect of investing to reduce the range of outcomes to provide a more certain result. An example of a deterministic analysis method is the use of decision trees. Decision trees illustrates the sequence of decisions and possible events that exist. It is common that the decision tree has three types of node. Squares represents a decision node, circles represent a chance node and a vertical line that represent the end of the decision tress (Okstad, 2006). An example of a decision tree is shown in Figure 11.20. The probabilities are indicated above the horizontal lines and the payoffs below. A complex problem can by utilizing decision trees be broken down into a series of sequential decisions and possible events (Hitt et al., 1989). By applying best practices for managing risk and uncertainty the operator can ensure that cost and schedule are properly documented and that estimates can be reproduced as a result of consistency (Peterson et al., 2005).

Schedules and Equipment Lists

Detailed scheduling for drilling operations are often used to visualize and list future activities. The detail and length of scheduling often varies, from a small number of activities in a depth time graphic or a more detailed scheduled with listing of activities and other related elements several days into the future. Detailed schedules often use a work breakdown structure that include and linked all activities required to execute the project. These plans can be fairly expensive and a drilling and completion operation can contain as many as a thousand of activities.

The Master Equipment List (MEL) is a simple WDP tool. The MEL identify all consumable and moveable items required to execute the operation at hand. It is also referred to as the bill of materials. The purpose of the MEL is to ensure that all items

[6]A synergy effect is the effect of two or more things working together to attain something that would have been impossible independently

are accounted for, as well as making the identification of item sources more easy. The list identify size and weights of critical lifting items so that transportation and handling are made more safe. It can also track the location of important items and be used to develop load out lists and ensure that rental items of importance are returned on time. The MEL is also a useful tool to allocate and manage availability and location of contingency items. The list format most often used is spreadsheet, making it user friendly and easy to share. Application of web based versions with pre-defined read and write access and simple version control is a solid system for managing consumables and other important equipment.

Estimation Techniques and Guidelines

Tools for estimating cost are also useful in a WDP.

Cost estimates for drilling and completion of wells has historically been made deterministic on the basis of the predicted drilling and completion program, with an extra 10% added as a contingency. However, the well execution phase has several uncertainty and risk elements that can be assessed when developing the cost estimate and adding an extra percentage to the cost estimate lack reasoning.

Probabilistic estimates on the other hand are better to determine costs as it takes into account the financial impact of existing uncertainties. A simple approach is to review the current cost estimating method and identify uncertainties that impact important elements of the work. These should be limited to approximately 40 to avoid simulation errors. Too many elements in a simulation will create an outcome that has a a lower range of uncertainty than actually exists and can be misleading. A way of solving this can be to divide the operation into discrete activity packages, e.g., hole sections, and apply the model to every package individually. The outcome is an plot showing cost versus probability, with common points of interest being the P10 and P90 value. The P10 is the point where the possibility of the cost being less than this is 10% and is often used as the minimum expected cost. The P90 is the point where there is a 10% of the cost being greater than this is 10% and is often used as maximum expected cost. It is common that these two points represent the range of expected cost. Another output of cost modeling is a tornado diagram that ranks the largest contributes to the cost range and enable a focus on managing their uncertainties.

Well known and fairly common tools are the use of guidelines, procedures and check lists. Guidelines provide information on how to proceed and act, while procedures provide information on how to proceed. Check lists provide detailed information about the work that should be undertaken and used to verify that the work is done. Check lists can be made very accurately and it is important that the employee responsible for incorporating these measures emphasize that it is mandatory to carefully follow the lists and avoid any slack. According to de Wardt (2010), a lack of rigidity can potentially lead to a mentality where the check lists are ticked off without confirming the quality of the action. This can compromise the value of the check lists and the entire WDP, as check lists are implemented to verify the well delivery process. If any deviation is discovered while going through the list, the person responsible must consult a third party to get the check list process approved. An example of a rigid use of check lists can be found in the airline industry where pilots are required to verify a check list before take off. The combination of discipline and sanctions for failing to properly process the check list help ensure that the list is used correctly in most cases. Procedures are often present where the instruction fit almost every situation and is repeatable. Guidelines, on the other hand, are often applied where the user must review the situation and make adaptions to successfully execute the operation.

	Project	**Ongoing Business**			
	Projects	**Job Shop**	**Batch**	**Repetitive**	**Continuous**
Description	One off	Customized	Semi standardized	Standardized	Highly standardized
Advantages	Maximize value of unique opportunity	Able to handle wide variety	Flexibility	Low unit cost, high volume efficiency	Very efficient, very high volume
Cost estimation	Complex	Difficult	Somewhat routine	Routine	Routine
Scheduling	Complex, subject to change	Complex	Moderately complex	Routine	Routine
Wells analogy	Exploration and Appraisal wells. Radically redesigned wells or a radical change in drilling / completion technology	Infill wells requiring unique solutions. New designs of wells in a well know region	Groups of infill wells with similar characteristics	Large number of identical wells with some defined options (Factory Drilling)	None

Figure 11.18: Features of different types of operations, distinguishing between the project mode and the ongoing business mode (de Wardt, 2010).

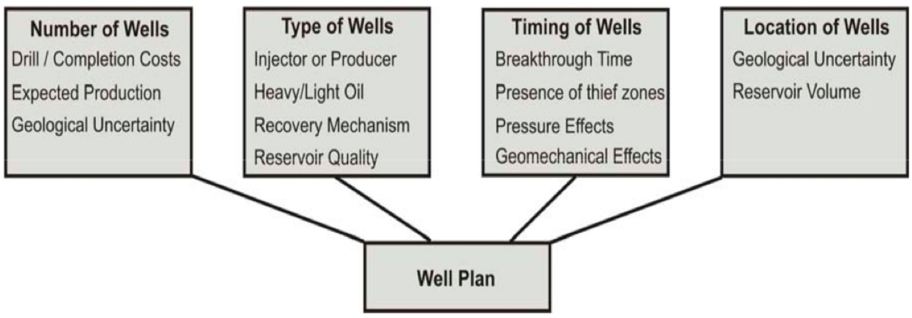

Figure 11.19: Primary elements to consider in well planning (McLennan, 2006).

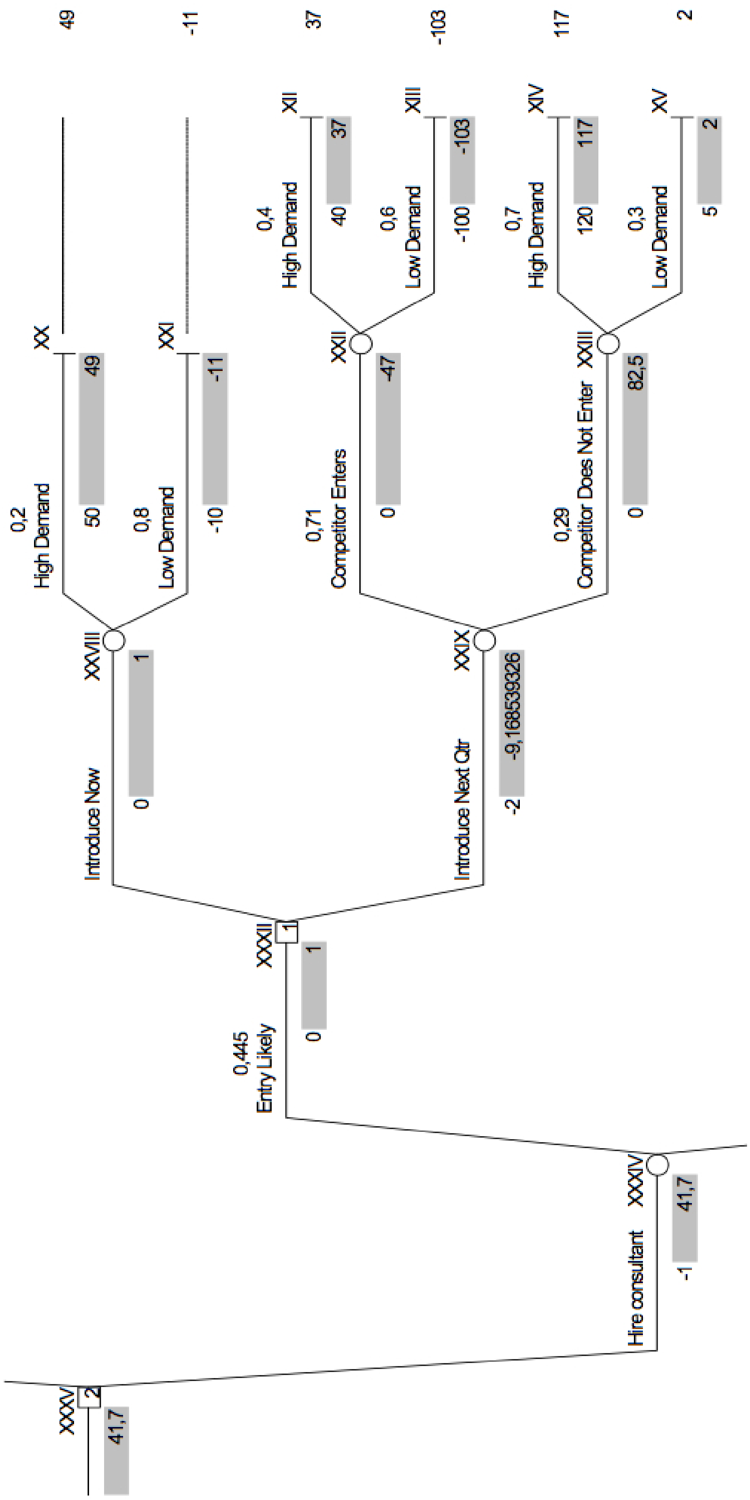

Figure 11.20: An example of a decision tree (Monahan, 2000).

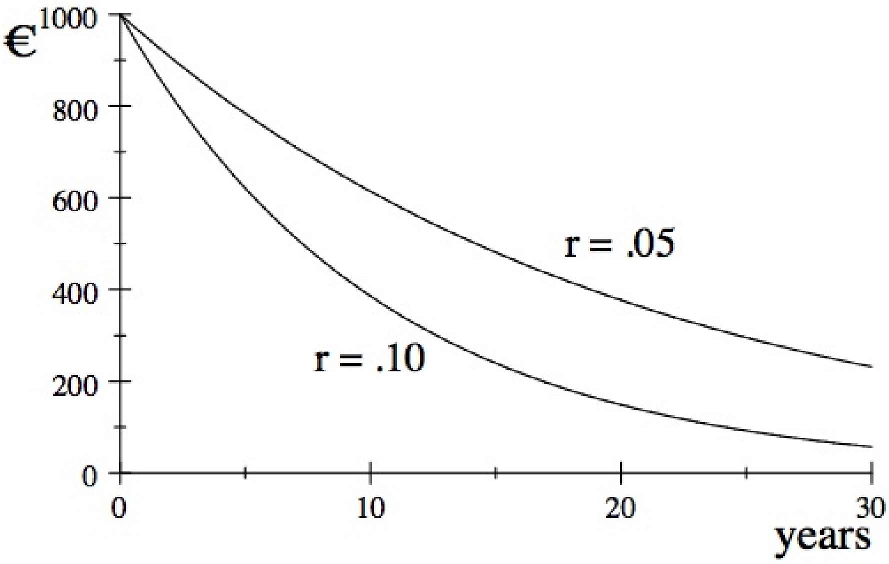

Figure 11.21: Value as a function of time (van der Wijst, 2011).

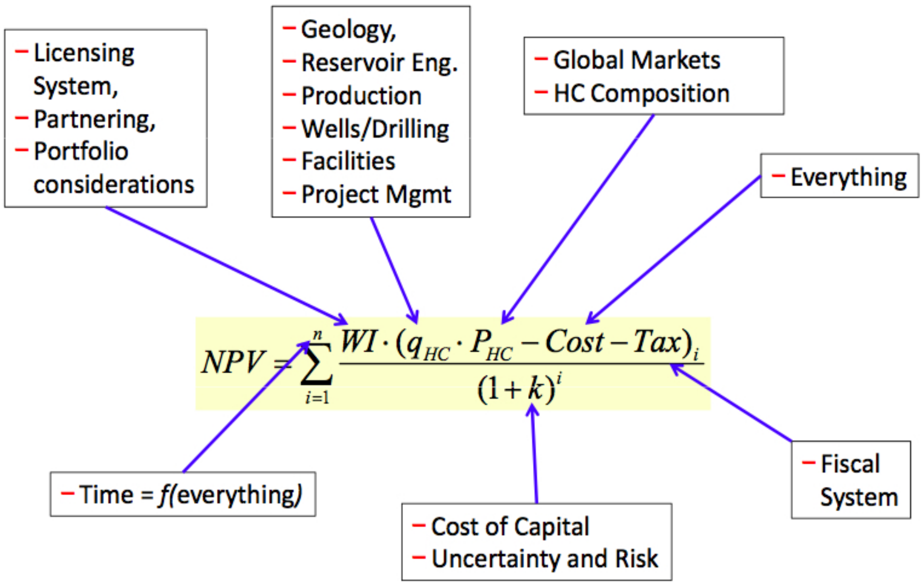

Figure 11.22: Deciding the Net Present Value of an oil field is a complex task with a lot of uncertain variables (Bratvold, 2011).