UNIVERSITY OF NORDLAND

BODØ GRADUATE SCHOOL OF BUSINESS

MASTER THESIS

Technology Development at the NCS

– Characteristics of Institutionalized Solutions

EN310E Energy Management

Sten Are Johansen
23.05.2012

Technology Development at the NCS – Characteristics of Institutionalized Solutions

Sten-Are Johansen

Universitetet i Nordland

23.05.2012

Preface

This master thesis marks the end of my master program of Energy Management at the University of Nordland and is my final work of a period that has been highly educational and personally developing. In addition to many interesting lectures during the Energy Management program the choice of thesis topic was crucial to my goal to get more in-depth knowledge about a topic that is essential to the petroleum industry and its future. Writing this thesis has been a learning process on many levels, both in designing and develop this paper and by acquiring more in-depth knowledge of the petroleum industry through contact with major actors in the industry.

I wish to thank my supervisor Anatoli Bourmistrov (associate professor, PhD) at the University of Nordland for leading me towards this interesting topic regarding industry technology and for providing me with tips on theories that could be relevant. Further his constructive guidance has helped improve the end-result of this thesis.

In the end I would like to express appreciation to my respondents that have put aside time for an interview in an otherwise hectic and busy working day. My respondents have provided extremely valuable information and given me the opportunity to learn by exploring into a very interesting data set.

Sten-Are Johansen

Tromsø, may 23, 2012.

Abstract

This thesis is exploring technology development at the Norwegian Continental Shelf by looking at the different stages in the process, the stakeholder's role and involvement in the process, and characteristics of institutional solutions that are chosen. The institutionalized solutions or standards can through theory explain why things are the way they are. The institutional technology development process that starts when a need or a problem demands a technological solution via product development arises, and through diffusion of that development. The objective of this thesis is to explore the different aspects of the process and point to obstructions or factors that are slowing down the process. To illuminate this process possibly entries to technology development has been explored from different perspective, the stakeholder's cooperation and contribution to technology development are explored, and in the end the authority framework was studied. The main conclusion of this thesis is that Norway has a good balanced framework with a high level of cooperation that stimulates technology development, but there are issues that are slowing down the technology development at the NCS. Some of the factors that have come to surface are; limited possibilities to participate in developments, limited funds for independent research, bottleneck in technology qualification, and 'new' environmental risks. All the factors that slow down the development basically boil down to awareness of required levels of funding and willingness and ability to invest. This might come out quite negative but Norway is doing all the essential things right and many good technologies are produced there. But for as a country like Norway with lot of potential and money could use this advantage to make technology development an even more prioritized area.

Sammendrag

Denne masteroppgaven har valgt å undersøke teknologiutvikling på norsk sokkel ved å se på de ulike stegene i prosessen, ved å se på interessenters rolle og involvering i prosessen, og karakteristikker ved valgte institusjonaliserte løsninger. Institusjonaliserte løsninger eller standarder kan gjennom teorien forklare hvorfor ting er som de er. Den institusjonaliserte teknologiutviklingsprosessen starter ved at et behov eller et problem krever en teknologisk løsning, til man utvikler et teknologisk produkt og prøver å spre det for å gjøre det til en kommersiell suksess. Formålet med oppgaven har vært å undersøke de ulike fasene av teknologiutviklingsprosessen og peke på faktorer som hindrer eller bremser teknologi utviklingsprosessen. For å belyse denne prosessen ble muligheter for deltakelse in teknologiutvikling undersøkt fra forskjellige perspektiver, interessentene samarbeid og bidrag i utviklingsprosessen ble undersøkt, og til slutt ble også myndighetenes rammeverk undersøkt. Hovedkonklusjonen fra denne masteroppgaven er at Norge har et godt og balansert rammeverk med et høyt nivå av samarbeider som stimulerer til teknologiutvikling. Men det er noen faktorer som bremser teknologiutviklingen som er funnet i denne studien er; begrensede muligheter for ulike interessenter til å delta i utviklingsarbeid, lite tilgjengelig kapital til selvstendig forskning, kvalifisering av teknologi virker som en flaske hals på resten av prosessen. Alle faktorer som bremser ned utviklingen koker i bunn og grunn ut i kunnskap om nivået på nødvendig satsning og vilje og mulighet til å investere. Dette kan høres noe negativt ut, men faktumet er at Norge gjør alt det essensielle riktig og mang gode teknologier blir produsert der. Men for Norge som et land med stort potensial og økonomiske muskler kunne ha brukt denne fordelen til å gjøre teknologiutvikling et mer prioriter området.

List of figures

Abbreviations

BAT – Best Available Technology

DEMO2000 – Program for Testing and Qualification of New Technology

EOR – Enhanced Oil Recovery (immobile oil)

FNI – The Federation of Norwegian Industries

FORNY (2020) – Commercialization of Research and Development Results

FPSO – Floating, Production, Storage, and Off-loading (unit/vessel)

GASSMAKS – Program for Increased Value Creation in the Natural Gas Value Chain

HAVKYST – Ocean and Coast; Precautionary-based Management of Marine Ecosystems

HSE – Health, Safety and Environment

IOR – Increased Oil Recovery (mobile oil and/or immobile oil)

JIP – Joint Industrial Project

MPE - The Ministry of Petroleum and Energy

NCS - The Norwegian Continental Shelf

NPD – The Norwegian Petroleum Directorate

NOK – Norwegian Kroner

NUST - The Norwegian University of Science and Technology

OLF – The Norwegian Oil Industry Association

O.E – Oil equivalent

PETROMAKS – Program for Increased Value Creation for the Petroleum Resources

PETROSAM – Program for Social Science in petroleum research

PIO – Plan for Installation and Operation

PSA – The Petroleum Safety Authority Norway

PDO – Plan for Development and Operations

RCN - The Research Council of Norway

SCM – Standard Cubic Meter

SDEA – The States Direct Economic Assets

CER – Centres of Excellent Research

CRI – Centres for Research-based innovation

Content Index

1. Introduction and Problem Statement

1.1 Actualization and Background

At the Norwegian Continental Shelf (NCS) the oil production is decreasing rapidly as the oil fields are maturing while new discoveries are few and far between. Now in the beginning of the 21st. Century most of the promising areas in Norwegian territory are presumed to have been mapped and the biggest and most easily accessible petroleum resources are already located, while new discoveries are mostly small and far between and much harder to reach and extract than in the past.

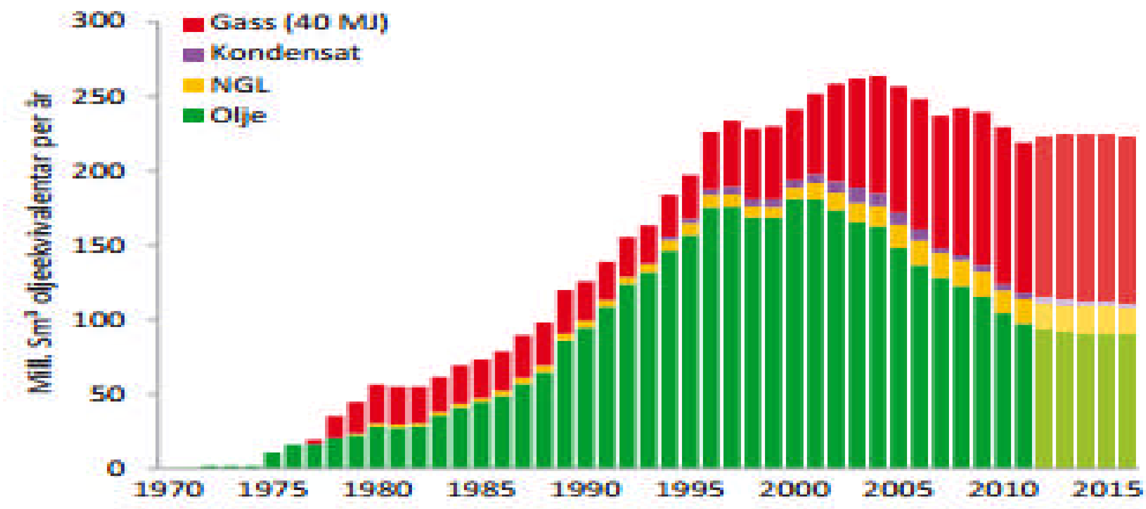


Figure 1 Norwegian Historical Petroleum Production (Source Faktahefte 2012)

The figure above illustrates the petroleum production in Norway measured in standard cubic meters (scm.) of oil equivalents (o.e.), and that it has decreased significantly since the top year 2000 when the production was 181 scm. o.e. Today ten years after the peak, the rate of production is 104 scm. o.e. (www.ssb.no)[1] which is at the same level as in the beginning of the 1990's when the industry was still growing. The drastically reduction in oil production of 43 percent has been compensated with increased production of natural gas. In 2000 the Norwegian natural gas production was 50 million scm. o.e. and in 2010 the production was 106 million scm. o.e. This is an increase that has more than doubled the gas production. Still the increased gas production does not cover the loss of oil revenue because of the negative

[1] http://www.ssb.no/ogprodre/

price gap between the gas and oil. With falling oil production, an increase of just 1 percent more oil recovery is enough to give a gross value increase of 270 billion Norwegian Kroner (NOK, or Euro 34,8 mill.), and that is with an oil price of $70 (report from the Extraction Committee, 2010, p. 17). With today's oil prices around $125 it's quite easy to see that this can generate extra income to Norway and the petroleum companies. The decrease in petroleum production in Norway is due to maturing fields which have reached their production peak and now faces challenges related to immobile oil, reduced pressure in wells, difficult drilling conditions and reservoir mapping. Hence the Norwegian authorities and the petroleum companies focus some of their efforts on increased and enhanced oil recovery (IOR/EOR) through research and development and other efforts that can increase production and exploitation rates of reservoirs. IOR and EOR is ways to increase the recovery of respectively mobile and immobile petroleum by techniques like injection of different compounds into the wells, improved seismic, etc.

While the production has sunk another concern for the petroleum industry is the fact that exploration for new resources have resulted in few and small findings last ten to fifteen years. Thus Norway's gross reserves of oil have not increase significantly enough to get production back to former peak volumes. With small discoveries new challenge related to innovative development have emerged, that is that small fields do not yield enough revenue to support development of technology which is needed to extract the resources. Many small discoveries are also in danger of not being developed because there is no existing infrastructure that they can make us off to make it economical viable, while other small discoveries have to be developed before nearby mature fields with available infrastructure is shut down. Thus there is a time limit for some technology developments as there is a deadline for possible production. In the figure below you can see that the growth of gross reserves has been low since a few years before the turning of the century and has even been negative in a couple of years.

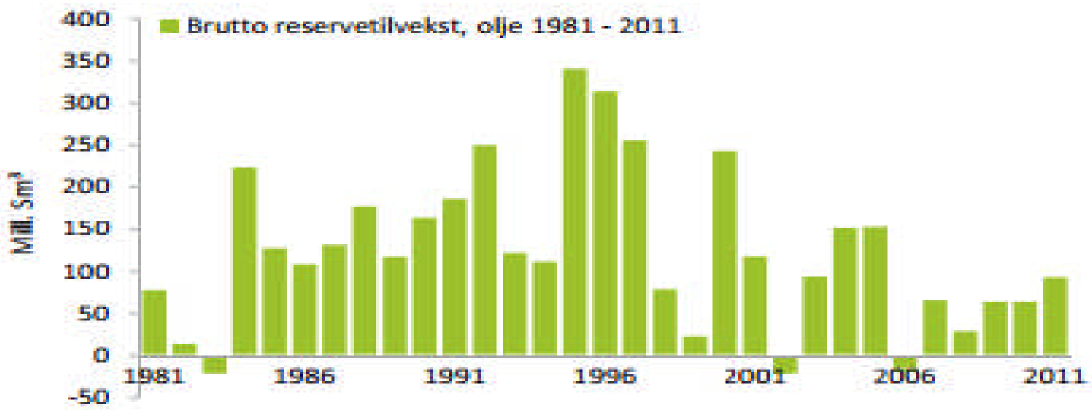


Figure 2 Gross Reserve Growth of Oil in Norway 1981-2010 (Source: Faktahefte 2012)

The biggest add-ons to the Norwegian oil reserves were made in the 80's and 90's and after the year 2000 there have not been any significant discoveries. Much of the reserve growth seen in the figure above is also just upward adjustments of existing fields, and accumulated reserves from many small discoveries. The exploration activity have been high during this period but still with poor results. Then after some 10 years with poor exploration results 2011 turned out to become a very successful year for new discoveries both in the North Sea, in the Norwegian Sea, and in the Barents Sea (www.aftenbladet.no)[2]. Many must feel relieved that their efforts finally are giving results and that they have done things right after all, because the doubt and pressure must have risen as new big discoveries weren't found while the production continued to fall. To most experts surprise the biggest discoveries were made in the North Sea an area that was considered to be thoroughly explored and on the brink of maturation, and not further north in the more unexplored Barents Sea. The amount of petroleum found at the Johan Sverdrup fields in the North Sea is so far estimated from 1.7 to 3.3 billion barrels of o.e. This makes it the third biggest exploration in Norwegian history, and equals 270 - 525 million scm. Another discovery in 2011 was the Norvarg field in the north of the Barents Sea with 225-260 million barrels of o.e. or about 35-40 million scm (www.aftenbladet.no)[3]. This field is not as easy accessible as those in the North Sea as it is located 190 km off the Norwegian coast. Even with today's technology it presents a sizable challenge to extract petroleum resources and sending it through pipelines to shore over such distances. In total 22 new discoveries were made in Norway during 2011 and will be a much needed addition of reserves, but according to The Norwegian Oil Industry Association (OLF) rapport for the petroleum industry in 2011 (economic report, 2011, p. 35); these new explorations in 2011 are

[2] http://www.aftenbladet.no/energi/aenergy/NCS-2011-oil-discoveries-hit-the-20s-2919112.html#.T0U9ufE7ok5
[3] http://www.aftenbladet.no/energi/olje/Norvarg-strre-enn-antatt-2891116.html#.T5VQl6vUP4Y

not big enough to prevent a falling oil production after 2020 so there is still need for exploration efforts in both perceived mature areas and new areas. Such new and attractive exploration areas have and are becoming opened, and one such place is the areas of Lofoten and Vesterålen in the Norwegian Sea where there is believed to be 1.3 billion barrels (206 million scm.) of extractable resources (Geo-technical evaluation of petroleum resources in the sea areas off Lofoten, Vesterålen and Senja, 2010, p. 22). This area is very important to many stakeholders and an area important to other industries and the marine life and wild life. For these reasons there is a huge dispute whether to drill for oil in these areas or not because of perceived high risks. At the moment the Norwegian authorities have decided to postpone the decision till the election year 2013 (white paper nr. 28, 2010/2011, p. 102). When the delimitation agreement regarding the common border with Russia in the Barents Sea was ratified new areas with huge potential have been added to Norwegian territory on the sea border to Russia. Norway started an impact assessment in this region in July 2011when the agreement entered into force. Eldbjørd Vaage Melberg, press spokesperson at the Norwegian petroleum directorate (NPD) stated that the gathering of seismic data will started in 2011 and that this activity that will run until 2013 ending the impact assessment (www.tu.no)[4]. The Norwegian authorities have high hopes that these new areas will reveal major discoveries but the authorities will not have any indications of the potential of these areas before 2013. Thus at the moment no one can say if and how much these areas will increase petroleum reserves. Since the beginning of the Norwegian petroleum adventure production volumes have been rising steadily, but since the year 2000 both the production and reserves have been dwindling due to maturing fields and few significant discoveries. New findings are often located in challenging areas; further offshore (Norvarg) and closer to the foreshores (Lofoten/Vesterålen), in deeper waters, with higher pressure and temperature. In Norway the petroleum companies that operate there have since the beginning relied on technology to discover, extract, develop, and produce products or services that generate income that can surpass the huge running costs involved. The difficult conditions at the NCS have also always been a constant trigger for technology development, and the climate and conditions in the area that is believed to be the future of the Norwegian petroleum industry, the Barents Sea, is much harder than in the North Sea and the Norwegian Sea. Thus technology will play an important role in making future resources located in distant and harsh areas available to the market. It is not even certain that discovered resources can be added to the reserves or put into

[4] http://www.tu.no/olje-gass/article287919.ece

production because inadequate technology, harsh conditions, environmental risks or other issues may hinder operations. The petroleum companies know by experience that technology can help increase efficiency and profits through the whole petroleum value chain, while reducing costs and risks and mitigate many of the challenges they face.

This background illustrates many of the challenges can be solved through technology development, and that these challenges make technology development important in relation to the offshore petroleum extraction at the NCS. Hence both Norway as a country and the petroleum industry is very dependent on a steady stream of technology developments to be able to utilize the natural resources at the NCS and to create as much value as possible from the extractable reserves. Up till now the petroleum industry in Norway have been successful in technology development, but the coming challenges and the advantages of technology development is so important for the future ability to extract petroleum that it is highly relevant to study the whole process.

1.2 Personal motivation

My idea for this thesis came about due to Norway's decreasing oil production, and the fact that the country needs more oil resources to meet future expenditures as the country faces an increase of elderly in the population who needs insurance and care. This combined with the discussion around the opening of the Lofoten and Vesterålen areas made the petroleum industry a very interesting subject for a thesis. In the summer of 2010 I read an article in the local newspaper (www.nordlys.no)[5] in Tromsø. In the article there were an interview with a tunnel expert that mentioned the possibility of drilling tunnels under the seabed of Lofoten and produces the oil through the tunnels, and at the same time mitigating many of the fears and worries stated by stakeholders. The tunnel concept seemed like a very innovative solution that could make these resources available and at the same time silence some of the critics to the petroleum industry by reducing the risks involved. Beforehand I wanted to write a thesis that would increase my knowledge of the petroleum industry, and a thesis with a theme that could be interesting to some of the actors in the petroleum industry. After I presented my motivations for the thesis to my supervisor he led me on the path of technology development at the NCS and I started to research in this direction. After researching the topic I realized that

[5]https://docs.google.com/viewer?a=v&pid=gmail&attid=0.1&thid=12eec128c47929ab&mt=application/pdf&url=https://mail.google.com/mail/?ui%3D2%26ik%3Df3d5edc967%26view%3Datt%26th%3D12eec128c47929ab%26attid%3D0.1%26disp%3Dattd%26zw&sig=AHIEtbR56HzF7rBGwXbjyfLDa_m4oTUd8A&pli=1

the topic was a very good and challenging one; one that is in the daily news almost every day, and that would enhance my knowledge with interesting data. By that the topic was chosen.

1.3 Research Questions and Contribution

Based on the background and my personal motivation the thesis is designed to explore technology development at the NCS with attention at characteristics of institutionalized solutions/choices that are part of this process. When a problem interferes with operations a need for technological development is created. Planning and developing a technological product includes many small factors that together makes up as process. After the product is finished developed it has to be marketed and made commercially successful. Each actor has their own motives and possibilities to be part of technology development but in many cases cooperation and joint efforts are crucial. I therefore also found it interesting to explore different stakeholders and how they work alone, or together with other corporations in this process. This led me to formulate the following research questions:

1. *How is technology development carried out at the NCS?*
2. *What characterize the institutionalized solutions that make up the process?*

Regarding the first research question the initial stages, including qualification, the aggregated data illustrate how the execution is at the NCS and emphasize obstacles or problem areas that the petroleum industry and authorities should be aware of. The second research question is related to institutionalization and is more complex since there are many aspects to institutionalization at the NCS. The process at the NCS unfolds in a certain way and institutionalized solutions and choices that are made 'standards' can help explain how and why things are the way they are. In this thesis institutionalization is used in three ways to describe; the fixed framework that surrounds the petroleum industry, the institutionalized process of technology development at the NCS, and institutionalization of the outcome of the process. The latter means technology developments that are the end-result of a technology development process, and which after development goes through critical phases that will decide if the technology becomes diffused and commercially successful. It is a theoretical discussion where the NCS is connected to issues in the theory that point to factors to that slows down technology development from being successful diffused and commercialized. In order to do this study I have taken starting point in three theories that I found relevant to the research objective and which can contribute to find the answer to these research questions. The chosen theories have within them models and other features that I have made use of in the making of this thesis, which will be further explained in chapter two.

A study carried out at the University of Nordland in 2010 has also looked into technology development at the NCS where the focus was the industry's general attitude to new technology development. My study differs from this in that study how technology development is carried out and diffused at the NCS by describing the stakeholders and their role in a development process, by examining crucial parts of the institutionalized process of technology development, and by examining important factors in the process of making a product become and stay commercially successful. The contribution of this study is that it is a thorough review of important aspects of the petroleum industry in Norway in relation to technology development. One get updated information on the petroleum industry and technology development efforts by reading this thesis and it will thus give the reader fresh data and better understanding of important processes. Areas that need improvement and that obstruct technology development and diffusion at the NCS will be highlighted, but at the same time I expect to find elements that point to fundamentals of success at as well. Therefore this thesis will be interesting reading material for the petroleum industry, authorities, and other stakeholder of the petroleum industry in Norway. The empirical data will be analysed with the already mentioned theories in mind, and parallels to the NCS will be discussed therefore the thesis should also be of interest to students, scholars, and researchers that have an interest in petroleum matters and theory. Hopefully this thesis can inspire and trigger ideas for further research within this topic and/or chosen theories.

1.4 Limitations

This thesis will explore technology development at the NCS, and institutionalization solutions in regards to the process. The petroleum operations are divided into several phases; the upstream, the midstream, and the downstream phase. This thesis will only deal with technology development related to the upstream phase and that are developed for petroleum companies as end-users.

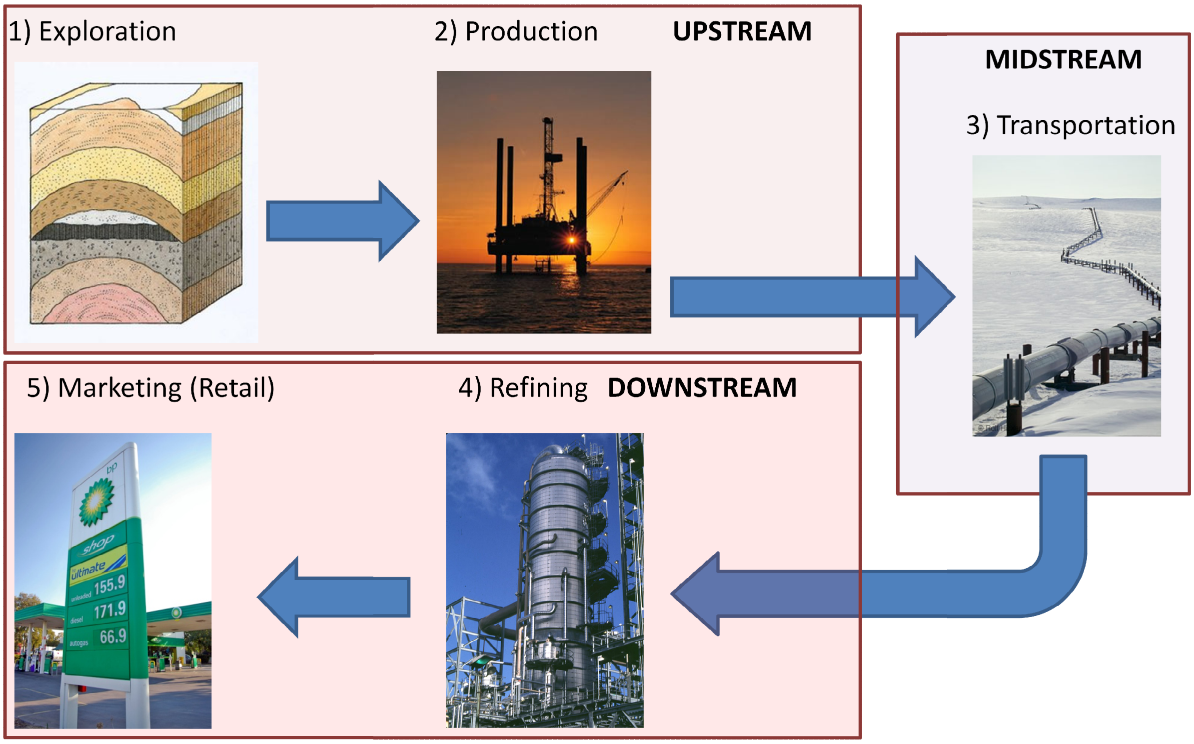


Figure 3 Phases in the Petroleum Value Chain (Bodgdan, Volostrigov, 2011)

As seen in the figure above the upstream phase include both exploration and production operations of petroleum offshore at the NCS, both will be considered. In the innovative theory there is a model for the development process and to limit the scope of this thesis I have chosen to disregard any information in regards to the last stage of 'consequences'. I have chosen to collect interview data from six respondents only, by telephone. All limitations are made to limit the scope of the thesis, to save costs, because of limited timeframe, and because of availability of respondents and data.

1.5 Structure of the Thesis

The structure and build-up of this thesis follows the standard requirements the University of Nordland sets for these kinds of reports. The thesis starts off with an introduction which covers the background for the thesis topic, why the topic is up to date and relevant, and my personal motivation, and research questions. The second chapter presents the relevant theories that are relevant to the topic and the thesis's objective and which have helped structure the thesis, collecting relevant data, and explain my findings by identifying the major mechanisms that are at play. In the third chapter the methodological choices made are clarified, before the fourth chapter presents the empirical data from both first and secondary data sources. In the analysis in chapter five empirical findings will be viewed in relations to relevant theories and the research questions, before a conclusion of the thesis is introduced in chapter six.

1.6 Further Research

During the making of this thesis I have come across many ideas for further research that could be interesting for next year's students, all of which is related to technology. The most interesting finding in this thesis is related to qualification of technology that deserves isolated exploration. The report from the extraction committee (2010, p. 46) mentions a term called "the valley of death" illustrating that it is a long period of time before qualified technology and tested international technology is utilized at the NCS, so it would be interesting to also take an isolated look at the implementation of technology. Further in one interview it was suggested that it would be capacity problems if they increased their funding, it could be interesting to find out if research institutes and universities have the enough good projects that defends receiving more funding? The last idea for further research is related to the Norwegian technology clusters and could be related to their success and the local geographical phenomena that have happened in several different pa in Norway. Why are they so successful? How does it spread to the near geographical surroundings?

2. Theoretical framework

2.1 Innovation Theory

When a petroleum stakeholder at the NCS decides to make technological change(s), they will start a process that helps them work in an effective way to implement the change. The innovation theory describes a process of innovation from the first stages of recognition of a need/problem and an idea to solve it, to the last stages where the innovation is spread and results and consequences are evaluated. This is a process that is more or less universal, but in different industries or businesses the process is likely to have differences or adaptations to special conditions. Further the theory mentions that all innovations have a beginning and an end, and that adoption of this innovation is related to technology performance.

2.1.1 What is an Innovation?

The definitions of the term innovation are many, but they all have a relative similar essence. A definition by Rogers (2003) states that an innovation is an idea, practice, or object that is perceived as new by an individual or other units of adoption. But this is still too elusive and needs further description. Fagerberg et al. (2009) states that; an innovation is a cumulative phenomenon. It builds on existing knowledge, including past inventions and innovations, while at the same time providing the basis for new innovative activity in the future (Fagerberg et.al. 2009). Economist Joseph Schumpeter was the first to draw the distinction between 'invention' and 'innovation'. According to this distinction, invention is a new combination of pre-existing knowledge, whereas innovation is more subtle concept. If an enterprise produces a good or service or uses a system or procedure that is new to it, it makes an innovation. In this view, invention – if present – is part of the innovation (Narayana, 2001). Viewed this way, an innovation includes both:

- A change new to both enterprise and the economy
- A change that has diffused into the economy and is adopted by the firm(s)

These two points' shows how much impact the 'change' needs to get in order to be classified as an innovation. If the changes are of such a magnitude as the two points mentioned above then it constitutes an innovation. Based on the definitions of innovation it's apparent that to be part of an innovative endeavour you can have an invisible idea, a process or way of doing things or it can be a product that is tangible. Either you have a tangible product or invisible service, common for both are that they are meant to solve a certain problem/need in a manner that is superior to the previous solution. It is often a perception that innovations have to be perceived as new, but it matters little whether or not an idea is 'objectively' new as measured by the laps of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If an idea seems new to the individual, it is an innovation (Rogers, 2003).

2.1.2 The innovative process

Innovations rarely just happen out of the blue and normally there is a process that helps organizations to work in a structured way to accomplish their objectives. In the innovative theory there is a model for the innovative process and the figure below illustrates the six phases in the innovative process developed by Rogers (2003), which is referred to as the linear innovation model.

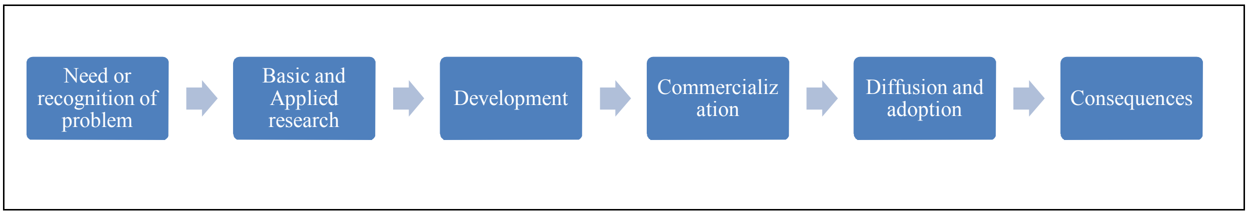


Figure 4 Phase's in the Innovative Process (Source: Rogers, 2003)

A competing model is the interactive innovation model that has directed critics of the linear model about it being to general and unrealistic, that not all stages are always used (e.g. research, commercialization, evaluation), and that loops between some of the stages is destined to happen and is absent in the linear model. It is true that for some innovations not all stages in the linear model are always necessary and in some cases redundant stages are simply skipped. However I need to examine all stages and any additional stages that might be special to the Norwegian petroleum industry. The critic concerning absence of loops between stages is not important to this study because the theory is in part used to become aware of important aspects to explore, but if loops occurs at the NCS I will make sure to highlight it. One thing that acknowledges the use of the innovative process is that the simple version of the interactive model is similar to the stakeholder model and therefore factors missing in the innovative process, but present in the interactive model, will be covered by stakeholder theory. Further and according to Isaksen (1999) the interactive model is a tool for analyzing innovative processes in low research & development intensive industries and small businesses, and thus seem not to be well suited to the petroleum industry at the NCS. As I didn't know the petroleum industry very well beforehand I was interested in a model that could help illustrate stages or phases that companies may have to consider and work through, and the linear model have just that, and since the critic of the model is not relevant here it was therefore preferred in the end.

The recognition of a need or a problem is the first stage of the process, and the motivation of those involved is that they want to solve this need or problem. In the scope of this thesis the recognition of a need or problem might come from the field operators, the Norwegian authority, or other actors at the NCS. Stage two and three are what theory calls the conversion stages with important efforts that lead to the desired solution or product, were the companies will develop and find solutions through careful planning and intense testing etc. The product is finished and utilize by a petroleum company if they have developed it themselves, or it can be a contractor (developers, suppliers, and service companies) who have responded to a request from a petroleum company and that have developed the product to them. Anyway the developer of a product would at this stage want to commercialize it by creating awareness amongst potential consumers and getting the initial sales. The fifth stage is about diffusion and adoption of the product. Diffusion is the process of which news of a product is distribute through communication channels over time among the members of a social system (Rogers, 2003). The company who created the product may use it themselves, but they may also want to earn additional profit by selling the technology to others. Companies will almost always try to get acceptance for their product and try to spread it in every direction since this lead to higher income for the innovative company. And as we shall see in the next sub-chapter; the better the performance of the product are, the higher adoption rate. The last stage is where the output and the whole process are evaluated and measured against earlier performances and expected result. Unfortunately in the petroleum industry this is easier said than done since it can take many years before one can see any results of development projects and it can even be difficult to make measurements of performance or point to certain areas that need improvement.

2.1.3 Technology Evolution

Once the product is developed and presented to the market, its evolution follows a reasonable stable pattern when it takes off and becomes commercially successful. This stable pattern of the innovations life-cycle is according to all theory shaped as an S-formed curve. According to Narayanan (2001) technology evolution refers to changes in performance characteristics of a specific technology over time. The S-curve represents and shows both the innovations development over time in relation to performance, and its shows adoption rates. The connection between the two is that adoption rates are dependent on improved innovation performance during its lifetime. This correlation is natural because good quality products attract more customers. The beginning of the S-curve represents the birth of a new market opportunity and development of a product, while the end of the curve represents death, or obsolescence of the product. The end of one S-curve also marks the emergence of a new S-curve – the one that replaces the current. In the figure below the x-axis represent product performance in A and adoption rate in B, while the y-axis reflects time in both A and B.

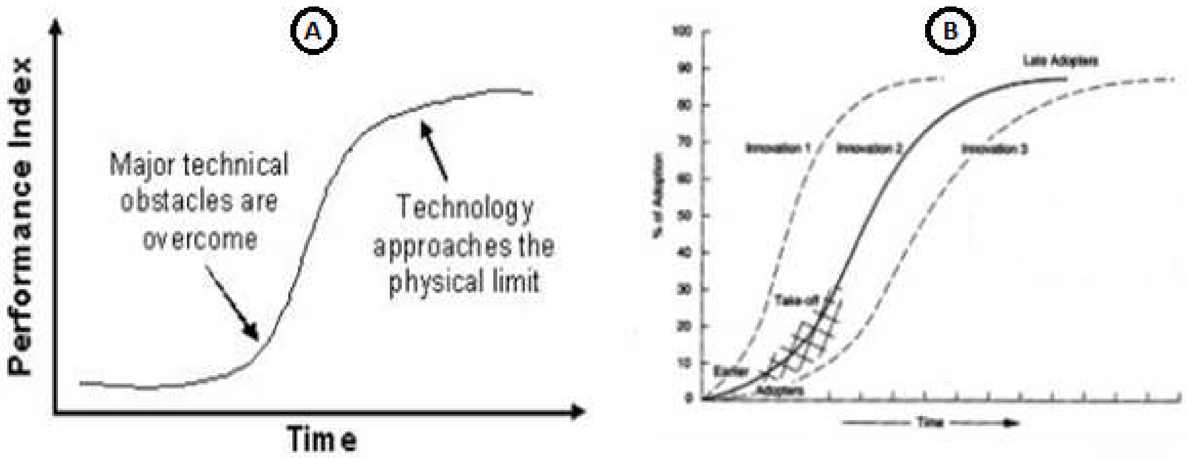


Figure 5 the S-Curve, Evolution and Life-cycle of Innovation (Rogers. 1995)

During the initial market release of a new technology product, according to the theory, the performance characteristics show very little improvement and adoption is limited to a small group of early adopters and small niche markets responding to a need or a problem. This is followed by a phase where the technology product shows rapid improvements in performance at an accelerating tempo, attracting additional adopters and thus winning higher market share. In the next phase the performance is flattening out and the before considered ‘new’ technology has now reached its maturity and further improvements become very difficult to achieve, therefore the amount of adopters are also flattening out and only a few late adopters are now acquiring the technology. If newer products are introduced to the market consumers will quickly shift and the new product will start eating market shares and replace this now old and mature product. But the consumers will only shift from old to new if the change includes an enhancement in performance beyond current levels.

2.2 Theory of Institutionalization

The theory of institutionalism has a wide variety of viewpoints amongst the researcher and deals with the organizational changes and how they happen. Organizational change is the change in formal structure, organizational culture, goals, program, or mission (DiMaggio and Powell, 1983). This definition is interpret to apply to technology and is within the scope of the petroleum industry that is always on the lookout for new ways to regenerate themselves technologically in order to increase their margins in a cost intensive industry. One perspective of institutionalization is that of 'Institutional Isomorphism' that deals with organizational change that leads organizations to become more similar to each other. Another perspective is the 'Institutionalization of Institutional theory' which covers the process of institutionalism; from changes in organizational structure and the path towards acceptance and diffusion of these changes until they are perceived as standard or natural.

2.2.1 Institutional Isomorphism

There are two types of isomorphic change; competitive and institutional. DiMaggio and Powell (1983) cover institutional isomorphism with its three mechanisms of institutional change. This view deals with the observed fact that organizations within the same organizational field often changes to make the organizations more similar without necessarily making them more efficient (DiMaggio and Powell, 1983). Most corporations do not wish to change unless it can enhance their performance, and thus in the context of the petroleum industry such changes are considered to be part of the host-country's framework that the stakeholder of that industry have to comply with. An organizational field are organizations that, in aggregate, constitute a recognized area of institutional life (DiMaggio and Powell, 1983). The initial organizations motive for change is triggered of a problem or need. But the later adopters of change are often driven by other motives such as becoming more similar so they are perceived as equal to organizations in their industry. According to DiMaggio and Powell (1983) highly structured organizational fields provide a context in which individual efforts to deal rationally with uncertainty and constraint often lead in aggregate, to homogeneity in structure, culture, and output. To describe this process of changes in organizations within the same organizational field DiMaggio and Powell (1983) use the theory of isomorphism. The three mechanisms that explain the organizational changes are coercive, mimetic, and normative isomorphism. This model take into account the vast environment the organizations have around them and the pressure each company experience from their environment.

2.2.1.1 Coercive Isomorphism

This type of isomorphism, as the name implies, has to do with forces of firm persuasion or collusion and is coming from the organizations external environment. The organizations have to comply with this external pressure if they want to keep their current position in the organizational field. This external pressure forces organizations, in the same organizational field, hit by the same pressure, to conform to certain 'standards' which in turn forces all organizations to change, and thus become more similar. In the context of the Norwegian petroleum industry the authority is an example of a very dominant power that can set the agenda for companies that operates at the NCS. The authorities have built up the industry in collaboration with petroleum companies, and the influences at their disposal (finances, laws/regulations, etc.) makes them capable of setting premises for the rest of industry. The authorities thus influence other stakeholders to comply with their premises but within limits. Laws and regulations regarding the petroleum resources in Norway and their content have not been investigated in the work of this thesis, but are merely acknowledged as being part of the framework for the petroleum industry.

2.2.1.2 Mimetic processes

Mimetic behaviour is about how organizations change in reaction to uncertainty by modelling themselves on other organizations. Uncertainty can be ambiguous goals, poorly understood technology, or other uncertainties created in the environment around the organization. Instead of finding the solution to this uncertainty internally, the organization turns to competitors or companies with similar attributes as themselves. The mimetic processes is a form of benchmark of best practice, were the organizations copy other organizations who they have found to have better solution to the perceived uncertainty. The organization that copies other companies reaps the advantage of saving costs, e.g. now unnecessary research and development. One example on how this might appear on the NCS is if one petroleum company wishes to adopt another petroleum company's technology to use in their own operations. If the mimetic process occurs at the NCS and a company or a group of companies model themselves after 'the best in the market' it seems only naturally to expect it to result in an industry where many of the same solutions are chosen by different stakeholders.

2.2.1.3 Normative pressures

The third mechanism is the normative isomorphism which stems from professionalization of managers and specialized personnel of large organizations. Professionalization is interpreted as the collective struggle of members of an occupation to define the conditions and methods of their work, to control 'the production of producers' and to establish a cognitive base and legitimation for their occupational autonomy (DiMaggio and Powell, 1983). There are two aspects of professionalization to organizational change. The first being formal education and legitimating which explains how the professionals, through the universities and professional training institutions, learn the normative rules about organizational and professional behaviour that is to become expected of them by their future employer. The second aspect is the professional networks that connect managers and specialized personnel in different organizations with one another for sharing of valuable information and experiences. Both of these aspects make the organizations more similar to one another. Companies tends to hire professionals and specialized personnel that have similar background and experiences, that the universities and other learning institutions provide, which enhance the effect of organizations becoming more uniform. When organizations in a field are similar and occupational socialization is carried out in trade associations, workshops, in-service educational programs, consultant arrangements, employer-professional school networks, and in the pages of trade magazines, socialization acts as an isomorphic force (DiMaggio and Powell, 1983).

2.2.2 Process of Institutionalization

The second perspective is the process of institutionalization presented by Tolbert and Zucker (1996), which explains the process from when a change occur to the change becomes the norm and adopted by most participants in the same organizational field. In an organizational field changes happens all the time. This model try to explain how and why some changes gain acceptance and is adopted by the majoriety of the companies. The model is stated to be most applicable to societies that are characterized by relatively weak national states, which is not the case in Norway. Still I have chosen to use this model because it contributes with many important and interesting aspects and have similarities to parts of the innovative process.

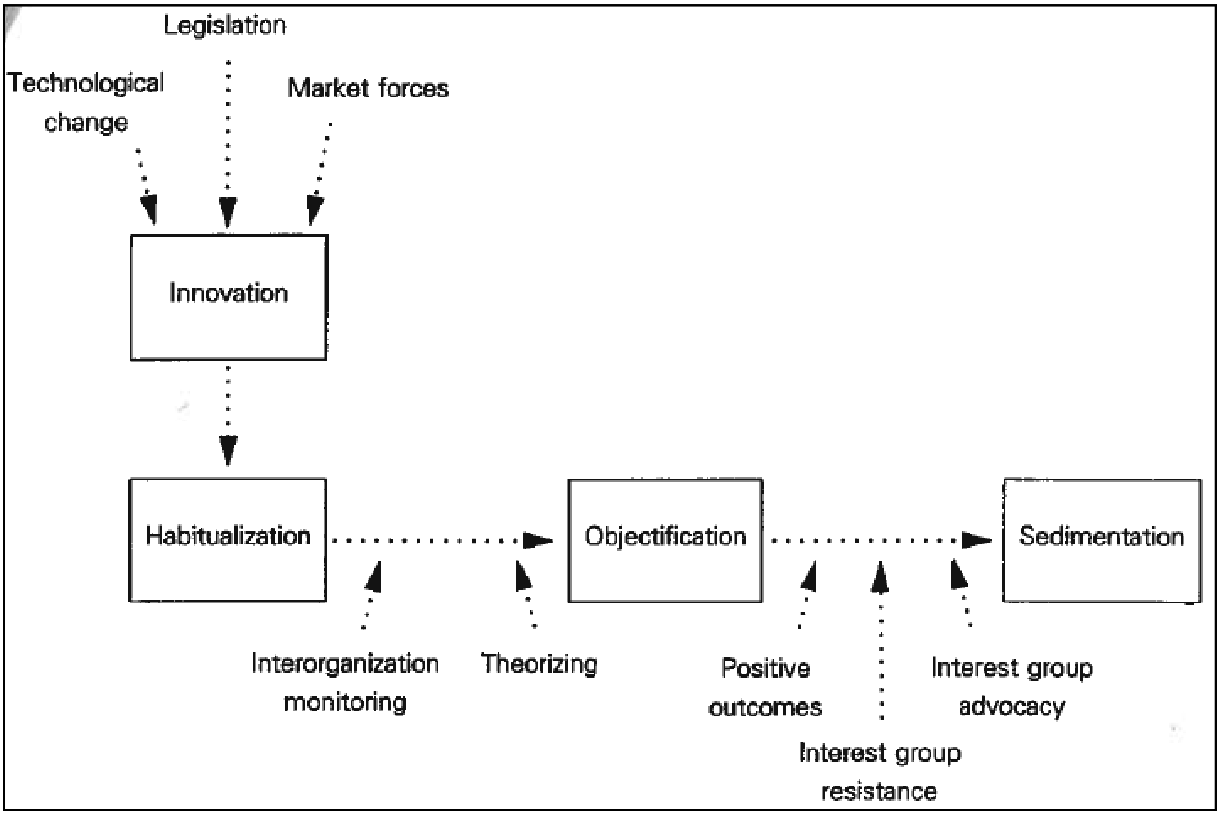


Figure 6 Component Processes of Institutionalization (Source: Tolbert & Zucker, 1996)

The theory is about how a organization, or a set of organizations, feel a need to change their structures, culture, production rutines, or the like. This change in organizational behaviour have been developed empirically and adopted by an actor or set of actors in order to solve recurring problems (Tolbert and Zucker, 1996). The causes for the change is illustrated in the top left corner of the figure above; new technology can become available or provide a new technological innovation that allows the organization to change some processes to the better. Secondly there can come new legislative regulations from the (host) government that organizations have to conform to and thus adapt and change. Thirdly but not least the market forces affects an organization in its dayily business. The market forces can make an impact in many ways and at the NCS it can be related to tanker/rigg rates, dollar value, interest rates, etc. In general it can be said that market forces disturb the status quo and the organization is forced to change to obey the revisions of the market or to keep up with the rest. This internally or externally induced pressure ‘forces' the organization to change in a way that is percieved as innovative. When some organizations make changes others will not neccecarilly follow automatically and in the following sub-sections the stages of habitualization, objectification and sedimentation will be reviewed in order to explain the processes that are innvolved when changes are spread from one organization to others within the same organizational field.

2.2.2.1 Habitualization

In an organizational context the process of habitualization involves the generation of new structural arrangements in response to a specific organizational problem or a set of problems, and the formalization of such arrangements in the policies and procedures of a organization, or a set of organizations that confront the same or similar problems (Tolbert and Zucker, 1996). In this stage the change or adoption is largely a independent activity and the number of organizations that adopt to these structural changes are few, and the manner they chose to implement them may differ amongst them. Adoption at this stage is predicted by characteristics that make a change technically and economically viable for a given organization and by internal political arrangements that make the organizations more or less receptive to change processes (Tolber and Zucker, 1996). Outsider organizations who do not have regular interaction with the adopting organization(s) are often quite unaware of the implemented solutions. There may be multiple adopters at this stage but they are few in numbers and most likely face similar circumstances that makes them prone to find the same solution, thought the implementation and usage may vary largely. Adoption is in sum explained by oppertunety and feasibility of change, and the organizations internal perception of uncertainty and risk in relation to change. At the NCS habitualization is about how the petroleum industry stakeholders alone or in few numbers have to make changes due to challenges that interferes with their operations, implementing and thus formalize the chosen solution.

2.2.2.2 Objectification

In this next stage the change has over time recieved some recognition and more organizations adopt to the solution in what is called the semi institutional stage. Objectification involves the development of some degree of social consensus among organizational decision-makers concerning the value of a structure, and the increasing adoption by organizations on the basis of that consensus (Tolber and Zucker, 1996). Under these circumstances managers in more and more organizations get their eyes open to this new structural change and find it to be of value. Diffusion can sometimes be spearheaded by what the theory referres to as a 'champion', which is someone that has a material stake in promoting the struckture. To be successful in promotion the product the champion must succeed with 'theorizing'; making potential customers see that this product is the solution to their problems. Managers can find a structure valuable by carfully monitoring the market and their competitors, and expecially those who have implemented this change allready. They can simply imitate and copy competitive adopting organizations, reassured by success of other adopting organizations. The logic is that if the change is proven valuable to similar organizations, the change should also be of value for them. Its easier and more cost effective to adopt someone elses innvention than trying to develop your own copy, and the more organizations that adopt it the safer the change is percieved by outsiders. Even though at this stage the structure has recived recognition and is more widly diffused some potential adopters will still be sceptical and may opt for their own tests to evaluate the changes value to the organization. Hence decision makers use information aquired from observing the market, evaluating choices of others, as well as their own subjective assessments, to determining if change is the best choice for their organization.

2.2.2.3 Sedimentation

Full institutionalization involves sedimentation, a process that fundamentally rest on the historical continuity of structure and especially on its survival across generations of organizational members (Tolbert and Zucker, 1996). This means that the structure is spread wide to all potential customers and that the usage is deeply rooted in each organization utilizing it. Tolbert and Zucker (1996) identified factors that affect the extent of diffusion and long-term retention of a structure as they saw it as key to understand the sedimentation stage. One such aspect that could truncate sedimentation is that interest groups collectively can mobilization against the structure. The second is that the structure will not be long enduring if it cannot display good results, and that customers are likely to abandon old arrangements over new and promising structures if that happens. Thirdly and last it is vital for the endurance of the structure that it has its own interest group that advocate for continued use and thus survival of the structure and in this way resists 'negative' interest groups. This also ensures continued cultural support of the structure. At this stage the structure is practically fully diffused and utilized by the majority that is viewed as potential customers. The structure has proven its durability and value to other organizations so new customers are easily adapting the structure with little or no doubt, individual tests or calculations.

2.3 Stakeholder theory

In the modern world businesses and business relations have become more complex as organizations and companies have changed dramatically over the last 20-30 years. Simultaneously our understanding of our environment and variable that affects it has grown. The basic idea of stakeholder theory is that business can be understood as a set of relationships among groups that have a stake in the activities that make up the business. Business is about how customers, suppliers, employees, financiers, communities, and managers interact to create value. To understand business is to know how these relationships work (Freeman et al, 2007). Thus organizations that want to be successful and achieve their goals (create value) need to know all their stakeholders and their relationship and interest to the business of the corporation. Stakeholder theory attempts to explain and guide the operation of the running corporation, viewing it as an entity through which multiple and not necessarily overlapping purposes are pursued (Hurst and Viber, 2004). Said in other words; stakeholder theory attempts to guide the organizations in their multiple business goals in relations to multiple stakeholders that have an interest in their business. One important contemporary challenge for manager is to achieve organizational goals while at the same time meaningfully addressing the concerns of their stakeholder and maintaining an advantage over competitors (Donaldson and Preston, 1995).

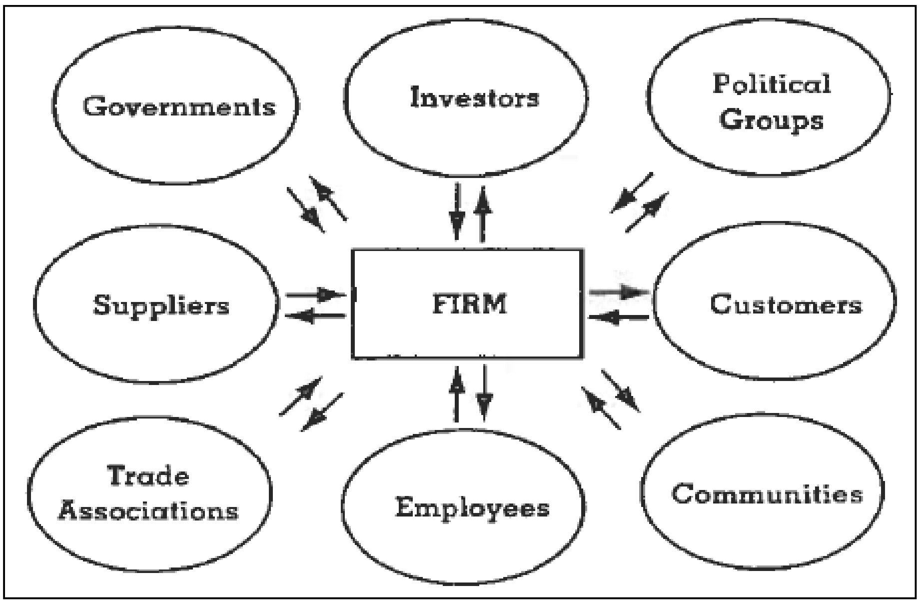


Figure 7 the Stakeholder Model (Source: Donaldson, T., and Preston. L. 1995)

As with other theories, the stakeholder perspective has numerous versions credited to it (Donaldson and Preston, 1995). In the figure above a model of a wide stakeholder definition and its complexity is shown. As illustrated all the stakeholders are grouped around the organization and arrows indicate that they have a two-way interaction with each other. The stakeholder approach can either be an ongoing process or just started in response to an impact to, or by the corporation. In any case organizations have to map and categorize stakeholders, estimate their power, and impacts to them. Thus stakeholder mapping can remind of a kind of due diligence and can be as deep and comprehensive as the corporation wish, and still one would rarely feel confident enough about the information that is collected. A corporation can always know more about possible positive and negative impacts that might hit the organization and stop them from accomplishing their goals. According to Hurst & Viber (2004) stakeholders are defined by their legitimate interest in the corporation, not the corporation's interest in them. But a even more accurate definition states that; any identifiable group or individual who can affect the achievement of an organization's objectives or who is affected by the achievements of an organization's objectives are to be seen as stakeholders (Freeman & Reed, 1983). Technology development in relation to the petroleum industry in Norway is a prolongation of the industry and hence stakeholders of the petroleum industry and stakeholders of technology development are considered to be the same stakeholders in this study. In the empirical chapter I have borrowed and slightly redefined the original stakeholder figure by placing technology development in the centre. Thus the stakeholders are viewed from the perspective of interdependent interest and involvement (role) in technology development in the Norwegian petroleum industry. With this adjustment the case of study in this thesis is the process of technology development and not one specific company. Technology development is the activity that can be understood as a set of relationships amongst groups of actors that have a stake in the petroleum resources at NCS, and how they interact with each other to create value of these resources.

2.4 Summary of Theories

In the technology development area within the petroleum industry there is a wide array of theories and models that are at play and that could have been used instead of the once utilized in this thesis. The choice of theories is decisive for the content and structure of the thesis in the sense that different theories will lead you to examine different areas of the topic that you are studying. Different theories emphasize different aspects and from different perspectives when they try to explain occurrences. In this thesis the theories that are chosen are closely connected with the research questions and factors that I perceived as important to explore in order to be able to solve the research questions. The collective explanatory power in some of the theories has been decisive in the choosing and usage of these theories. Other theories that could have been relevant have been left out because of limited time to review all of the possible theories. In this thesis the stakeholder theory helped identify all relevant stakeholders and interpret their affiliation with the technology development processes and sort them into manageable groups. Thus it has functioned as a structure for getting an overview of the industry, the actor's role, and how the actors contribute to the process of technology development. In the figure below the used theories and their shared influence over the topic in this thesis is illustrated.

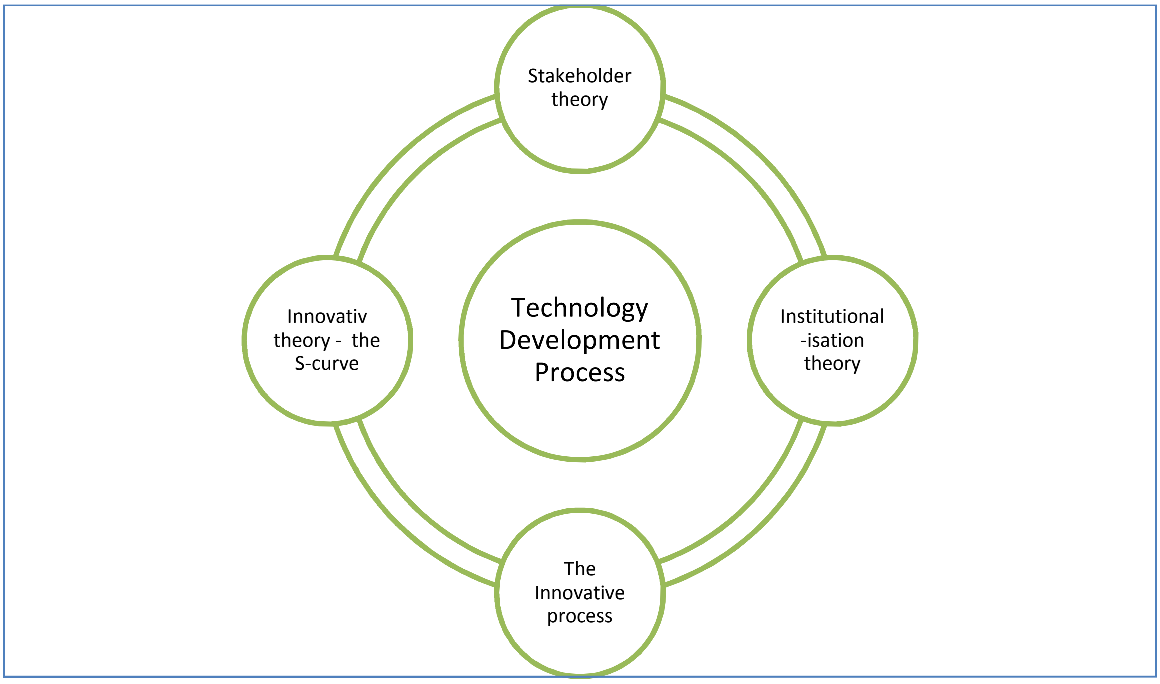


Figure 8 Theories utilized and Shared Influence over the Technology Development Process

The innovative theory is used for all its phases that are very much relevant to technology development process. The innovative process was also used as basis for structuring the interview guide and also provided essential definitions that are important to have clarified. Isomorphism explains how constraints works as a framework that forces organizations to change in ways they would not do if they could chose. Furthermore the S-curve of innovative theory has some explanations in relation to the levels of adoption in conjunction with an innovations performance over time. The process of institutionalization is used because it helps explain which mechanisms that are in play from when an need occurs to a solution is created and diffused, and in the end becomes the norm for solving a specific challenge. In sum the theories help explain how the technology development process unfolds at the NCS, by looking at institutionalized solutions, and which stakholders that contributes, with what where, in the prosess.

3. Methodology

This chapter explains choices I have made regarding thesis design and the direction this has lead me in, in relation to structure of the thesis. By reading this chapter you will learn that the chosen design is an exploratory case study shaped to collect rich qualitative data concerning technology development process at the NCS through semi-structured interviews and secondary sources. Further this chapter discusses important elements of sampling and explains why my six respondents divided onto five stakeholder groups are considered a good sample size. Explanation of how the data has been analysed is followed by an evaluation of the validity and reliability in this thesis, before the chapter ends up with ethical considerations that had to be considered and addressed.

3.1 Research Design

The research design is about how one chose to organize the research, including colleting of data and ways to analysing data in a manner that best answers and explains the research questions. According to Ringdal (2007) there is mainly three types of objectives in a research project; explore, describe or explain. This thesis's objective is to explore technology development at the NCS, taking starting point in the innovative process and stakeholder theory. While I have explored into the development process the focus has also been on institutionalization, that is to explore state of affairs and understand why things are the way they are. I have chosen to use a case study where the unit of analysis is technology development at the NCS. The case study method is defined and understood in various ways and according to Easterby-Smith et al. (2008) a case study looks in depth at one, or a small number of, organizations, events, or individuals, generally over time. According to Berg (2009) a case study involves systematically gathering enough information about a particular person, social setting, event, or group to permit the researcher to effectively understand how the subject operates or function. Because of my exploratory objective and that these and other descriptions of case studies fit with what I had in mind I am convinced that an exploratory case study is the best research design for this thesis. An exploratory study objective is to gather as much relevant data as possible and get as much knowledge out of it as possible, which sometimes can result in quite 'open' or 'wide' problem statements or research questions like this thesis, but it comes natural of the objective of the thesis.

3.1.1 Qualitative Research Design

There is an important distinction between qualitative and quantitative research design. The former involves collecting data that is mainly in the form of words and the latter involves data which is either in the form of, or can be expressed as, numbers. The researcher has to make a careful and deliberate choice as to what form his data should have and what is most appropriate data form to answer the problem statements. And even the problem statement will be formulated differently depending on if methods and data are of qualitative or quantitative nature. In studies with a quantitative touch it is common to use hypothesis, while qualitative studies form problem statements as questions. Hence this thesis uses research questions. Researchers can choose between these two methodologies or a combination of both, but as this thesis' is designed as an explorative case study it is appropriate to collect qualitative data in form of words to get as rich and informative data as possible. Qualitative and quantitative methods can be used fittingly with any research paradigm (Denzin & Lincoln, 1998). Looking back history of research is bursting with positivistic and quantitative research methods much because sciences like math, physics, and biology were established before social science. In recent years, however, strong counter pressures against quantification have emerged through social constructionism and other paradigms. According to Denzin & Lincoln (1998) this counter pressure focuses on the exclusion of meanings and purposes in quantitative studies. Quantitative research function well in some studies, but some of its weaknesses is that it can be inflexible and is not so good for the purpose of generating meanings and understanding. The use of qualitative research on the other hand will often give a greater depth of understanding (Berg, 2009). This confirms that the use of qualitative methodology is the appropriate design for this thesis since the objective of this thesis is to acquire understanding and generate knowledge.

3.2 Data Collection

The primary data contains of recorded telephone interviews transcribed into text and the secondary data is also mostly in textual form, with the exceptions of an excel file containing numbers of authority funding of petroleum research. Both primary and secondary data have required different methods of data collection and the results from each source have then been put together and analysed in the context of the research questions.

3.2.1 Primary data

Primary data or empirical data is collected by the researcher him- or herself. According to Easterby-Smith et al. (2008) collecting one's own research data gives control over both the structure of the sample and the data obtained from each respondent. This gives greater confidence that the data will match the study objectives. Collecting one's own data also has its disadvantage as it can be both a very time consuming and a costly affair. To circumvent some of these disadvantages I have conducted the interviews through telephone which has saved me both time and costs of travelling to the respondents. I also suspect that it is much easier to get respondents to participate if they know that it is just a telephone interview with a beforehand agreed time limit. Time used to transcribing the qualitative data is an obvious disadvantage of collecting qualitative data one one's own, which I experienced firsthand as the time saved on telephone interviews was spent on transcribing interviews. I believe that it is a good idea to transcribe the interview as soon as possible after they are done while the interview is still fresh in the researcher's mind. If the researcher are conducting several interviews in one day this could be difficult to manage. Bad sound quality is a risk and a disadvantage with recording interviews as it sometimes can be difficult to hear what is said on the recording. There are a number of reasons to why this can happen, like that the respondent talks low, background noises interfering, dialect and language issues, low or empty battery, etc. Transcribing the interviews right after the interview will help the quality of the data in such cases since it is easier to record the data accurately because you still remember the conversation. In almost all interviews I did there were moments where I had doubt to what was actually being said when I was listening to the recordings. My experience is that this is something to be aware of and that happens at some point in almost all recorded interviews no matter how good quality of the recording. Another disadvantage of telephone interviews can be that you only have data in the form of words, and you miss the body language, facial expressions, clothing style, etc. which could provide additional information to the data set.

3.2.2 Secondary data

Secondary data already exists and is gathered from free sources or bought from research institutes and the like. This can be governmental documents, public or private databases, reports, articles, internet sites, annual reports, etc. The obvious advantage of using secondary data is that it saves the researcher both time and money so that he can get up to date on already produced research and the topic in general. According to Easterby-Smith et al. (2008)

the downside of using secondary data sources it that the quality of the data may be more uncertain, and the researcher does not have control over either the sample or the specific data collected. The secondary data made use of in this thesis is for the most part official reports and other data from official sources about the technological situation at the NCS, hence I feel very confident regarding the quality. The data has contributed with background information and valuable knowledge that was important to acquire before I could started to think about doing interviews. Besides the theories in chapter two this backdrop of knowledge in form of secondary data has helped me to get acquire a base of knowledge that further lead me to find important research elements and relevant topics for the interviews.

3.2.3 Semi-structured interviews

Because of the objective and chosen research design interviews were considered the most appropriate data collection method for this thesis because it supplies rich textual data. The first thing I had do decide upon was how much structure I would have in the interviews. According to Easterby-Smith et al. (2008) there are three main types of interviews related to structure; highly structured, semi-structured and unstructured interviews. Again the purpose of the research would direct the researcher towards what is most appropriate structure of his or her interviews. Highly structured interviews are best suited for market research, polls, taste etc. where the answers in general are short. This kind of interviews is also good for producing quantitative data, and do not fit well with my research design. According to Easterby-Smith et al. (2008) Interviews, both semi-structures and unstructured, are appropriate methods when:

1. It is necessary to understand the constructs that the respondent uses as a basis for his or her opinions and beliefs about a particular matter or situation
2. The aim of the interview is to develop an understanding of the respondent's 'world' so that the researcher might influence it, either independently, or collaboratively
3. The step by step logic of a situation is not clear; the subject matter is highly confidential or commercially sensitive; and there are issues about which the interviewee may be reluctant to be truthful other than confidentially in a one-to-one situation.

All of these terms and conditions are present in my study, and in the end I chose to use semi-structured interviews. I have a conviction that semi-structured interviews are better than unstructured interviews for this study, because it gives me more control over the interview situation and the topics that I want to cover. This means that instead of letting my respondents' just fire away on technology development at the NCS I made an interview guide or a topic guide before I started doing interviews. In the interview guide I have four main topics that I wanted to discuss. Under each topic I had made three-four questions that I initially felt were necessary to touch upon, while the rest of the information would come from the respondents association with the topics and my open questions. I had made sure that I had weeded out questionnaire errors and asked questions in an order that would let the interviews progress in logical fashion. After a few interviews the main topics were still intact but I soon realized that the answers to my 'support' questions were identical independent of respondents. As my knowledge grew I gradually started to ask new relevant questions off the top of my head and I asked follow-up question when I felt that I needed additional information or when something was unclear. As the data collection progressed and interviews were undertaken I felt more confident about the topic and what I wanted to know. Hence not all respondents got the exact same questions as I adjusted my questions to the respondent's roles and function and what I already knew and needed to know. All in all I feel that I managed to create an interview situation where the respondents felt comfortable and provided me with lots of relevant and accurate data.

3.2.4 Sampling

In order to be able to make inference about technology development at the NCS one need to collect data from organizations and people involved in this process, and in this study the whole population are organizations involved in the petroleum industry in Norway. The term population refers to the whole set of entities that decisions relate to; while the term sample refers to a subset of those entities from which evidence is gathered. The inference task then is to use evidence from a sample to draw conclusions about the population (Easterby-Smith et al. 2008). At the NCS there are clear segments of groups; oil companies, contractors, government, interest-groups, and research institutes. This would yield a sample size of five respondents if one chose just one respondent from each group. In four of the five stakeholder groups I have settled with just one key respondent because of both limited timeframe and the belief that respondents in the same groups of organizations will for the most part have the same viewpoints (normally distributed), and thus would not have contributed with much extra information. The only stakeholder group with two respondents are the authorities, but initially I also wanted to have a second respondent from the petroleum companies so that I had both a big and a small company, but Statoil abstained from participating in the last minute. I sought to interview two respondents in each of the two groups as they are major players that in many cases set the agenda when it comes to innovative developments at the NCS.

	Realist (Yin)	Relativist (Eisenhardt)	Constructionist (Stake)
Design	Prior	Flexible	Emergent
Sample	Up to 30	4–10	1 or more
Analysis	Across	Both	Within case
Theory	Testing	Generation	Action

Figure 9 Key Features of Case Method Informed by Different Ontologies (Source: Easterby-Smith et al. 2008).

One can easily say that the variations in case study design and application are complex and can even in some cases blend into each other, as the figure above summarizes some of the main distinctions in the application of case methods according to three basic research Ontologies (Easterby-Smith et al. 2008). Ontology is about how researchers perceive and interpret, philosophically, the reality they live in or study. Said very short I position myself somewhere between relativist and social constructionism when it comes to social science, but in the bigger research picture it all depends on what is being studied and what the objective is. The latter paradigm assumes that there is a reality which exists independently of the observer, and hence the job of the scientist is merely to identify, albeit with increasing difficulty, this pre-existing reality (Easterby-Smith et al. 2008). In relation to the sampling the figure shows that constructionist and relativist case studies typically settle with one to ten respondents, which makes me confident that I have a good sample size with my six respondents.

In order to find appropriate respondents I have used a non-probability sampling method which contains elements of quota sampling, snowball sampling, and purposive sampling. In non-probability sampling the researcher does not base his or her selection of samples on probability theory, rather efforts are undertaken to create a kind of quasi-random sample to have a clear idea about what larger groups the sample may reflect (Berg, 2009). My sampling strategy has been to divide the organizations into stakeholder groups according to their role and function and choose one (or two) key person in each stakeholder group that could be a representative of that group. This is similar to quota sampling which divides the relevant population up into categories and then select until a sample of a specific size is achieved with each category. Together with stakeholder theory quota sampling was a good tool to divide the actors in stakeholder groups. When developing a purposive sample, researchers use their special knowledge or expertise about some group to select subjects who represent this population (Berg, 2009). Snowball sampling starts with someone who meets the criteria for inclusion in a study, who is then asked to name others who would also be eligible (Easterby-Smith et al. 2008). When I was deciding on eligible respondents, whom I should pick for interviewing from each of the groups, I used both knowledge I had, tips from my supervisor, and advice from my respondents The advice was both regarding suitable companies/agencies and appropriate persons that have relevant information and knowledge about the topic. By acquiring and using this information to find suitable respondents it has elements of both purposive sampling and snowball sampling within it. I wanted to speak to people that were involved in innovative development processes, and preferably people high up in the organizational system or who has worked in the industry for some time. Except from the Statoil drop-out I feel that I have been very lucky with the respondents that I managed to obtain, and I learned a lot from conversation with them. In this study I have interviewed:

- Knut Aaneland director of technology at North Energy
- Bente Nyland director general at the Norwegian petroleum directorate
- Inge Carlsen special advisor at SINTEF
- Gøril Tjetland CCS advisor at Bellona
- Reidar Müller senior advisor at the Ministry of Petroleum and Energy
- Runar Rugtvedt branch manager for oil and gas at the federation of Norwegian Industries

3.3 Data Analysis

The empirical data collected for this thesis is gathered through semi-structured interviews with quasi random picked respondents. The interviews have been recorded and later transcribed into written text. One disadvantage of doing interviews, recording them and then transcribing them into written text, is that this is a process that will require a lot of valuable time. The best solution would be to outsource this task which would save time, but this often entails a cost for the research project. Even though it takes a lot of time to do this job it has also an advantage in that it allows the researcher to get more acquainted with the data which is always a good thing. The number of pages transcribed into text in this study is by no means a big data set, and is thus manageable without the use of any computer program. After transcribing the data into written form I have 34 pages of text from six interviews. All the interviews were organized in the same way and followed the same progression regarding themes, which made it quite easy to sort and analyse the data. The initial 34 pages of data was then washed and cleaned of unnecessary information and put into one ‘interview analysis document’ and sorted according to the four themes in the interview guide. The statements from the different respondents were put in different colours so that it was easy to distinguish the statements from each respondent in the ‘interview analysis document’. The statements from the ‘interview analysis document’ were then used when writing the thesis, and the statements that had already been used were stricken over by a function in Word. Statement’s that were redundant was stricken over twice by the same function in Word. In addition to this effort I also read every interview several times using them for control and double checking making sure that important aspects were not forgotten or misunderstood.

3.4 Validity and Reliability

In research studies it is normal to be concerned about the studies validity and reliability. According to Ruan (2005) research procedures offer great safeguards against error, but error can still make its way into scientific findings. Humans can make mistakes in executing the methods of research – e.g. by contaminating evidence, selecting biased samples, poor interpretation of data, etc. Attention to validity and reliability is necessary to make sure that such errors do not occur. Validity is about the concerns of the study is measuring what it is supposed to be measuring, and consist with issues of both internal and external characters. According to Easterby-Smith et al. (2008) a case study carried out in a relativist fashion typically have similar concerns related to validity as a positivist study. That is whether the instruments and questionnaire items used to measure variables are sufficiently accurate and stable. The contrasting position, which is informed by a constructionist epistemology, is much less concerned with issues of validity in case studies and more concerned with providing a rich picture of life and behaviour in organizations or groups (Easterby-Smith et al. (2008). In this case study validity concerns are relates to the researcher, the interview guide and the respondents and their statements. I have had to ask myself: have I asked the right questions? Can I trust the statements given to me? Have I and the respondent understood the situation and/or topic correctly? And have I chosen appropriate respondents? All of these concerns are related to what is called internal validity. The respondents did not always get the exact same questions, but I feel certain that my questions are relevant and according to what I want to measure. I am confident that I have covered all necessary aspects through my interview questions, which was partly confirmed by some of the respondents who said that I had good questions, and that the interview was interesting to be part of. In the end of each interview I also asked every respondent if they had something to add, just to make sure that I did not overlook anything. I have no reason to doubt any of my respondents and the statements and interpretations they have provided me with, but all the time I have had in the back of my mind that each respondent have their own perspectives based on where they work and which position they hold. One thing that is bad for the validity is that Statoil chose not to participate, and without their 'side of the story' the data set is not as good as it could have been.

External validity is in one part about if the findings in a study can be applied beyond the study that created the findings. The question is; can the results of a study be generalized to other settings? In this study the generalization has not been a major concern because much of the purpose of the study has been to collect data to get a good and rich picture of the topic, and not for generalisation purposes. A qualitative study with a small sample size like this one, typically have low external validity so generalization to other settings is more doubtful in this case. Still other technology driven industries or businesses can find similarities in this study compared to their own development procedures and processes. Another part of external validity is about the robustness (reliability) of the study; that is if the study can be replicated over and over again with the same results every time. I firmly believe that the results from this thesis can be replicated in other studies, with both different researcher and respondents. The only reservation is that it is carried out in the same manner, with same design and execution. The interview situation may be difficult to copy exactly, but my impression after the interviews is that the topic is well known, the information flows in the open, hence other researchers would very likely end up with roughly the same' data set after the interview. All else being equal the only issue that could reduce the reliability assessment slightly is that different researchers might interpret the data differently and thus come up with a different conclusion. Because of my sampling strategy I am also very confident that my sample has provided me with very rich and good information that can be generalized to that of the population.

My research design, choice of respondents and their positions and the fact that this topic is well known and not very sensitive gives me confidence to claim that this thesis have strong validity and reliability, and thus without mistakes or biases of any kind.

3.5 Ethical considerations

Bell and Bryman (2007) have conducted a content analysis of the ethical principles of nine professional associations in social science. They identified ten principles of ethical practice where the first seven are about protecting the interests of the research subjects or informants, while the last three concerned ensuring accuracy and lack of bias in research results. When doing research and collecting data from respondents there is always the possibility that the respondents put their name and reputation and even their job at stake when they give their opinions that is later printed and up for scrutiny. The researcher needs to 'protect' his or her respondents with tools like anonymity, shielding sensitive information from the public, not to interpret their statements etc. In order to protect the informants I have made sure that the respondents are fully aware of the purpose of the thesis and what contribution that I expect from them. This is to avoid misleading the respondents of the nature of the research and to make sure that I got as precise data as possible. I wanted to record the interviews to make sure that I understood accurately the information, the context in which it was given, that I didn't neglect any information given, and to be sure that I reproduce their opinions correctly in the study. Recording the interviews was also preferred because of my lack of being able to write notes. Every respondent were asked in advance if they had any reservations against this method of data collection, which none of my respondents had. In some cases the respondents may feel uneasy with the use of a recorder, most likely because if they wished to they would have difficulties going back on statements that can be played back as 'evidence' later, and it is more problematic to claim wrong quotation. There was no need for anonymity of respondents in this study as I have interviewed respondents that have official positions, and their answers reflect this position. No respondents have uttered the need for anonymity, and thus they stand by what they have said by name. In order to ensure lack of bias every respondents were sent the transcribed interview so that they could read through it to make corrections or adjustments to their statements if they pleased. No major changes were made by the respondents after the interviews.

4. Empirical Data – Technology Development at NCS

4.1 Stakeholders of the Petroleum Industry in Norway

To be part of the resource extraction at the NCS there is an embedded need to be innovative, and technology development is seen as a competitive advantage to be in front, much because of the harsh conditions but also because of demands from the authorities. The stakeholders of the petroleum industry in Norway are defined as actors that in some respect have an interest in the industry. Stakeholders of the petroleum industry and stakeholders of the process of technology development are considered to be the same stakeholders since technology development is a crucial part of the petroleum industry. Technology development at the NCS is a system that is driven by governmental efforts, private and state owned companies, contractors (service companies), research institutes, universities, and the community. The technology development at the NCS is driven forward by collective efforts from these multiple stakeholders'. In this study I have via secondary data mapped and divided the stakeholder into five groupings according to their role and function which can be seen in figure 10 below. By replacing a specific company in the centre with technology development and placing the stakeholders around the topic of the thesis it gave me a starting point for my further research.

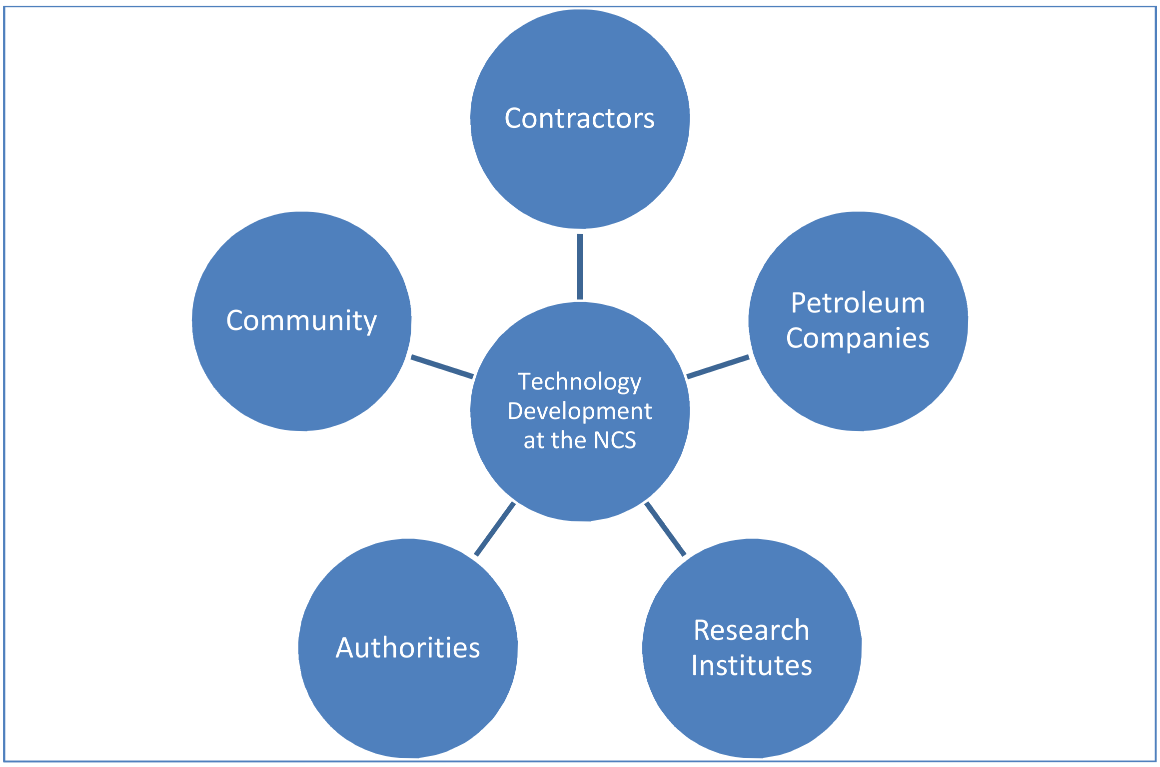


Figure 10 Technology Development at the NCS and Stakeholders by role and function

All groups in the figure are stakeholders that have an interest in technology development in some respect; either it is the authorities with its funding and regulations, the research institutes that are making some research report, or the community that voice their opinions. The main contributors to technology development are those who invest the most into research & development, namely petroleum companies and contractors. The authorities' also plays an essential part, which will be described shortly. All stakeholders play a significant, if not equal, role even though the efforts, motives, and budgets may vary across and within the groups.

4.2 The Authorities and Their Organization of the Petroleum Industry

After many discoveries, especially after the Ekofisk field began production in 1971, it became clear that there were great values at the NCS and a need for a good way of organizing the business. The government wanted a strong national ownership and strong governance. The challenge with structuring the petroleum sector was to get a system in place that would help the management of petroleum resources – a system that would maximize value for the whole of the Norwegian people and the Norwegian community (Faktahefte 2010, p. 18). It was also important for the oil companies to be able to make rational decisions on their investments, and thus it was a prerequisite that the framework was predictable and transparent. Organization of activities, roles and responsibilities ensures that important social considerations are taken into account, and that value creations are made in the name of the commonwealth. At the same time the views of the environment, health, working and safety environment plays an important role. In 1972 the Parliament adopted a tripartite approach with regard to how the state should deal with its involvement in the petroleum sector. Politics, Government and business were split in the following way (the Norwegian Petroleum Museums yearbook, 2008, p. 46):

1. The political responsibility for matters related to petroleum was put in its own section within the ministry of industry. In 1978 the Parliament established a separate oil- and energy ministry.
2. The NPD was established to be responsible for resource management and safety regulations. That is, the NPD collect and process geological and geophysical material from the NCS, and controlling that the petroleum industry is in compliance with the law and the safety and working regulations at the NCS.
3. State oil company Statoil AS was established to safeguard the state's business interests.

4.2.1 The Parliament and Government

The organization of the petroleum industry today is not very different from the initial, except that it may now be seen more as a quadripartite and not a tripartite as originally. Over the years there have been small changes back and forth but in 2001 the authorities' structuring of the petroleum industry changed more significantly with the establishment of new state owned companies. In 2004 the petroleum safety authority Norway (PSA) was established and today the NPD shares their old duties, and new ones, with the PSA. Presently the authorities have organized their tasks related to the petroleum industry as seen in the figure below.

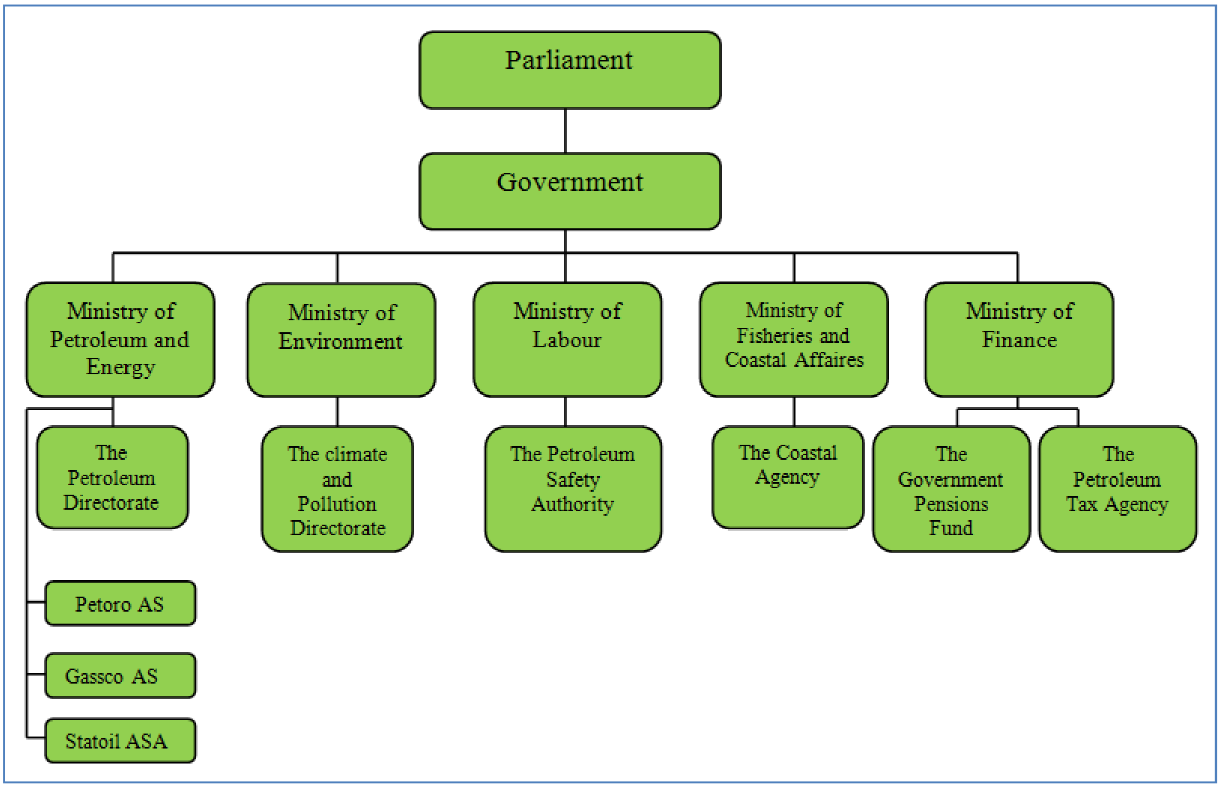


Figure 11 Governmental Organization of the Petroleum Industry (Source: Faktahefte 2012)

At the top is the parliament, which sets the framework for the petroleum sector in Norway with laws and regulations and they also controls the government and the public administration. Major development issues and principal matters are discussed there. Some of the laws and regulations that function as framework and facilitation for the industry and innovative development are the income tax, the accounting agreement, and the tax agreement for innovation. *The Norwegian income tax system* for petroleum operations is based on ordinary company taxations of 28 percent. Since the petroleum industry is especially profitable they are subject to an additional tax of 50 percent. The total taxation level on petroleum operations is hence 78 percent in Norway. This is slightly higher than most other countries with petroleum resources, which have taxation rates in the range of 30-60 percent on petroleum activities (Report on International Petroleum taxation, 2008, p. 9). The Norwegian taxation system gives incentive for petroleum development projects in that it provides good conditions for depreciation of investments over time and deduction of all relevant costs, including costs related to exploration, research & development, financing, operations and removal (Faktahefte 2012, p.16). With these favorable conditions for depreciation and deduction the actual taxable amount can be much lower as long as there is continued investment in petroleum projects and research & development efforts in Norway. In this way much of the risks involved in petroleum projects are taken by the authorities. Deduction of costs related to exploration also gives petroleum companies incentives to try new methods/developments etc. to locate petroleum resources, and if they do not find anything or the methods fail they will receive a reimbursement of most of their costs. Through *the accounting agreement* the operator companies can receive refunds of costs related to research and development. In order to get this refund the companies have to document that they have used the investments as the license requires. The investment shall be used for research and development with relevance for the NCS, and do not have to have any specific relevance for the license they operate. The financial agreement contributes to significant amounts being channeled from the industry into technology development and projects of importance to increased recovery (report from the Extraction Committee, 2010, p. 37). Another scheme is *the tax agreement for innovation* (SkatteFUNN) which is an agreement that was established in 2002 and is Norway's largest effort on research and development directed at small and medium sized businesses. The system is administrated by the Research Council of Norway (RCN) in collaboration with the organizations Innovation Norway and the Tax Administration. SkatteFUNN is an agreement that gives, small and medium sized businesses operating in Norway, a deduction in taxes of 20 and 18 percent respectively of costs in approved research & development projects. The criterion for approved projects are that they must be aimed at obtaining new knowledge, or new skill which may lead to new or improved goods, services or production processes (www.forskningradet.no)[6].

The government has the executive power of petroleum policies and are accountable to the parliament for its policy. The government is responsible for handling day to day business and make sure strategies and plans are followed in all efforts related to petroleum. In order to

[6]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1222340152207&pagename=skattefunn%2FHovedsidemal

exercise the policies the government receive assistance of governmentally established ministries and their subordinate units. The MPE is naturally the focal ministry when it comes to petroleum matters, but all of the ministries in the organizational chart presented previously have duties related to the Norwegian petroleum industry:

- The Ministry of Labour is responsible for Health, Safety and Environment (HSE)
- The Ministry of Finance is responsibility for the income to the state
- The Ministry of Fisheries and Coastal Affairs are responsible for oil spill prevention
- The Ministry of Environment naturally have responsibility for environmental issues

In the following only the authority agencies that have closest ties to the petroleum industry and innovative developments are brought into the light.

4.2.2 The Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy (MPE) states that; "The research & development in the petroleum and energy sector is a prioritized area for the government" (www.regjeringen.no/en/dep/oed)[7]. The petroleum sector is a major source of revenue for Norway, and future value creation in the petroleum sector depends on how effectively they manage to exploit the remaining resources at the NCS. To accomplish this in a best possible way they have a need and interest for continued technology development. The MPE's primary mission is to facilitate a coordinated and comprehensive energy policy, and for this they have established four departments where oil and gas is one of them. Here they work to facilitate and organize the petroleum sector requiring them to have dialogs with politicians, other ministries, supporting organizations, and miscellaneous agencies. Further the MPE has the responsibility for the resource management and the sector as a whole. To be able to manage this daunting responsibility creation of governmentally owned companies has been vital. Subordinate to the MPE some state owned companies have been established to help manage the industry and Statoil AS is one example of a wholly state owned company that was established in 1972 to safeguard the state's business interests related to the petroleum sector. But as the income from the petroleum business grew it became clear that there was a need to separate this Statoil As cash-flow into a company part and a state part. Today the state only have approximately 67 percent ownership in Statoil ASA the rest is in private hands. When

[7] http://www.regjeringen.no/en/dep/oed/Subject/energy-and-petroleum-research.html?id=86983

Statoil ASA was listed on the stock exchange in 2001, PETORO AS was established as a fully state owned company managing the states direct economic assets (SDEA). The SDEA consists of the authority's portfolio of assets at the NCS, being licenses, pipelines and onshore facilities where the state has direct holdings. Gassco AS is another fully state-owned company established in 2001 to be the operator of the pipeline network and the major onshore facilities for gas. These state owned companies (only Statoil ASA not fully state owned) are all subordinate to the MPE and is established to help organize and manage the petroleum industry and its development.

4.2.2.1 Strategizing for the Future

The need for a coordinated national effort in petroleum related research & development led the MPE to formation of the board of Oil & Gas in the 21st. Century (OG21) in 2001. This is a work group established to help the petroleum industry to formulate a national technology strategy for added value and competitive advantage in the petroleum industry, necessary to mitigate the challenges the petroleum industry is facing in the 21st. Century. The duty of the board of OG21 is to develop a national technology strategy for the Norwegian petroleum industry and serve as advisor for the authorities and businesses. The purpose with OG21 is to ensure an effective and environmental added value of the Norwegian oil and gas resources through a coordinated engagement, in the petroleum cluster, in education, research, development, demonstration and commercialization (www.og21.org)[8].

In response to its duties OG21 released a strategy document in 2001 with a focus on strategic areas of technology that are appropriate to increase the reserves and maximize production at the NCS, and to achieve a cleaner and more energy efficient production while at the same time maximizing added value through export of technology. The strategy has been revised a couple of times, and last time it was revised was in June 2010. The main goal of the OG21 strategy document is to create an environment where all the actors participate and pull together towards common goals related to the research & development activities. In short: to unify the research & development activities towards the common challenges at the NCS. The OG21-strategy is also designed to function as guidelines for public spending and as a foundation for technology strategies within the oil and gas industry. In the strategy document the worst case scenario is mentioned as a possible outcome if the government doesn't take

[8] http://www.og21.org/servlet/Satellite?c=Page&cid=1253962785364&pagename=og21%2FHovedsidemal

their role seriously; "Government involvement is important to stimulate research and development of high expertise that can be applied in Norway. Without incentives the industry can come to move research activities abroad. The increasing competition from abroad makes it necessary for the authorities to undertake a long-term commitment and support of the supplier industry in Norway (OG21 Strategy Document, 2001, p. 15).

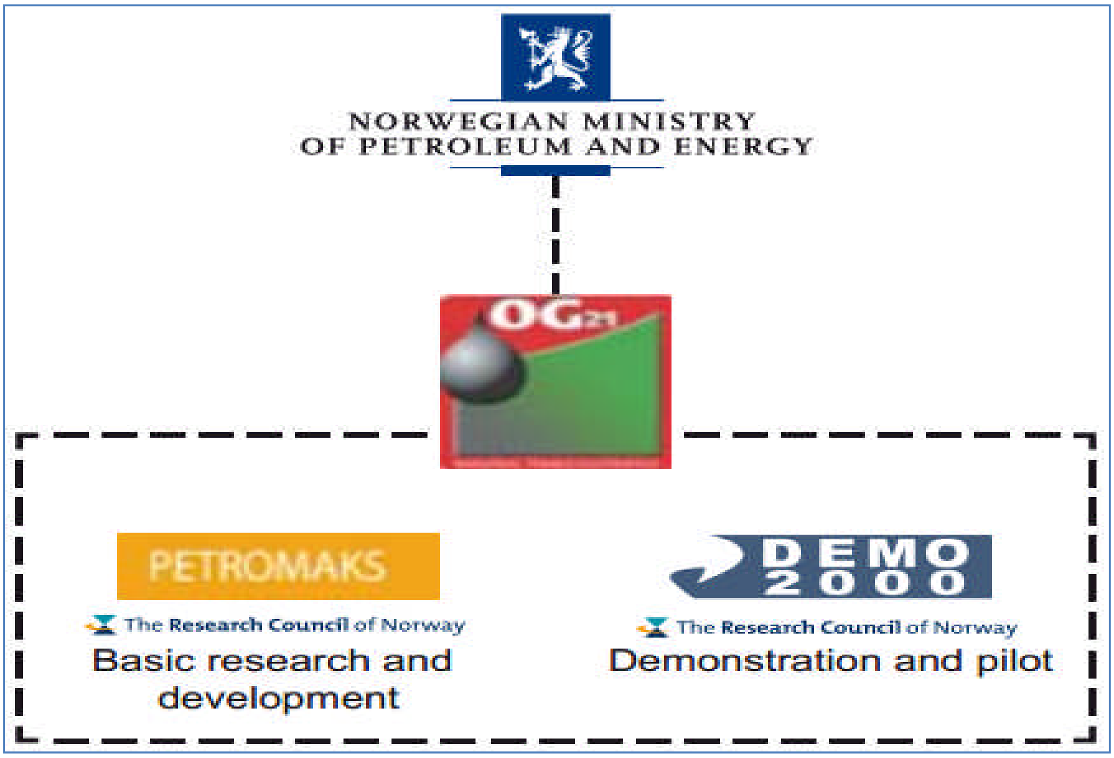


Figure 12 Ministry of Petroleum and Energy's main involvement in petroleum research (Source: Faktahefte 2012)

The main technology target areas of the OG21 strategy are:

1. Value creation through production and reserve replacement; Increased reserves by five billion barrels of oil by 2015
2. Energy efficiency and cleaner production; Maintain Norway's position as the oil and gas province with the highest efficiency, lowest level of emissions to air and the lowest levels of harmful discharges per produced unit
3. Value creation through increased export of technology, to continue the current growth path with annual sales of oil and gas technology of 120 billion by 2012
4. Value creation through employment and skills development; Maintain and further develop Norway's position as a leading and competitive cluster in the oil and gas technology

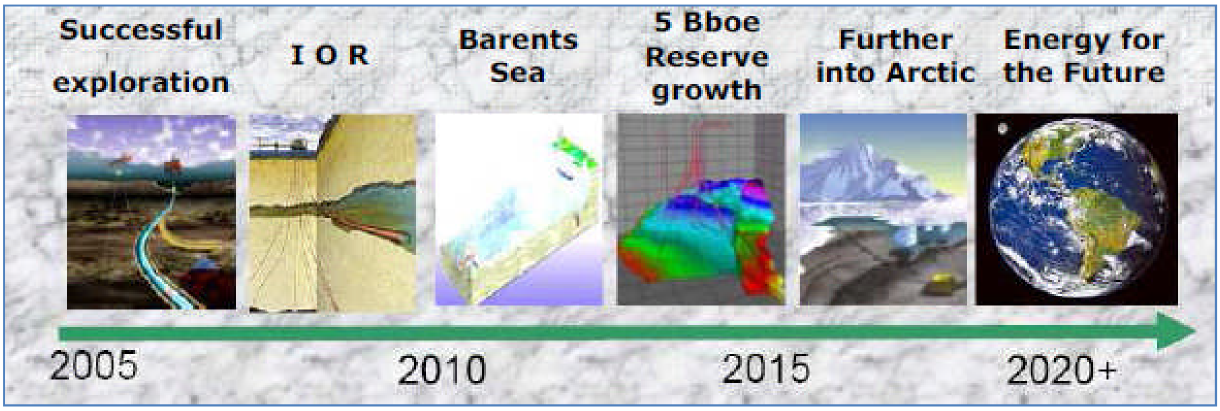


Figure 13 OG21's Technology Roadmap for Value Creation at the NCS (Source: OG21 Strategy Document)

To reach the technology targets four task forces have been put together; Energy efficient and environmentally sustainable technologies, Exploration and enhanced recovery, Cost effective drilling and intervention, Future technology for the production, processing and transportation. The OG21s' board estimates that to implement the strategy the public spending to research and development activities towards the petroleum industry needs to be in the range of 600-800 million NOK (OG21 Strategy Document, 2001, p. 3). The major barriers that have been solved and need to be overcome in the future to meet goals and targets set are illustrated in figure 13 above - challenges and expected technology progress in the future.

4.2.2.2 Authorities Funding of Petroleum Research & Development

Another role of the MPE in relation to technology development is that they are responsible for allocating funds for research & development, and to distribute them in a cost effective way to get as much value as possible from the input. As already mentioned the funds from the Norwegian authorities to petroleum research are channelled through the RCN. According to Bente Nyland (2011) the decision of how much funding, to what purpose, and to who is a process where the MPE, the government and the parliament are the only governmental agencies involved. The MPE each year have a budget conference where they prepare research proposals for new priorities and how much funding that is needed. Reidar Müller (2011) states that; "when the MPE follow-up the RCN we can make constraints on priorities, but at the same time we often ask the RCN for advice and them to us, it's a two-way dialog". In this it can be understood that the MPE do not set allocations without consulting other relevant governmental agencies first. Then allocation proposals are sent to the government that either accepts or rejects the proposals (Reidar Müller, 2011). The authorities funding of petroleum research have been a relative fixed amount of approximately 400 million NOK in recent years, and if some additional proposals are accepted or rejected this will either increase or decrease this fixed amount. The governmental financing is mainly prioritised towards education, basic research, long-term technology and stimulation of pilot testing of technology.

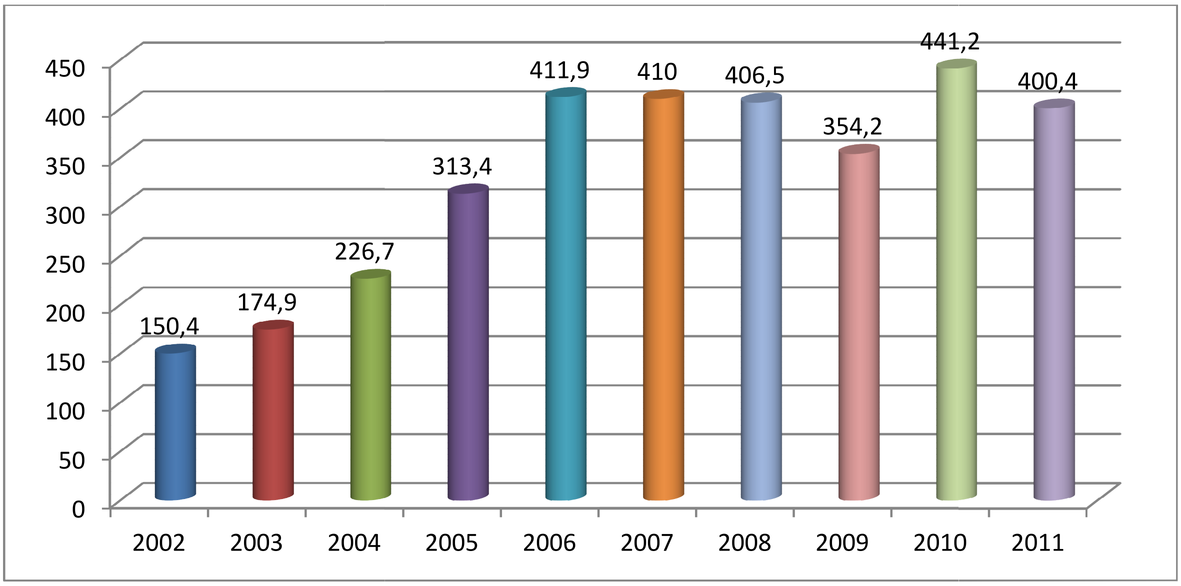


Figure 14 Governmental Grants to Petroleum Research (Source: RCN, appendix 2)

From the figure above we can see that the governmental funding of research has increased since 2002 with a top in 2006. 2010 is the actual year that received the most governmental funding, but this was because of the Norwegian stimulus package which increased the funding with 50 million NOK that year. The stimulus package was a response to the recession in 2008/2009; otherwise the total sum in 2010 would have been just 390 million NOK. The OG21's board has, as mentioned earlier, estimated that in order to implement the strategy and get as much value out of the NCS as possible the governmental grants to petroleum research and development needs to be around 600-800 million NOK each year. This constitutes quite a gap between the amount stated in the OG21 strategy and the authority's spending of around 200-400 million NOK. The perceived lack of will to increase the governmental funding gives some of the actors of the innovative process a feeling of resignation towards the present government, and they are hoping for better conditions after the next election in 2013. Several of the interviewees expressed this frustration by suggesting that the governmental funding are peanuts compared to what is really needed, and especially toward piloting (Runar Rugtvedt, 2011). Knut Aaneland (2011) feels that the authorities can be some narrow minded sometimes and should have a wider perspective because the Norwegian society receives 90 percent of the income from oil and gas, thus there is little risk in increase the amount to petroleum research with one billion or more. This view is supported by several others who mention different reasons why more funding is needed; the Extraction-Committee (also called the Åm-Committee) released a report in September 2010 stating that the need for increased funding to petroleum research is needed because of maturing fields. They mention that time is of essence if the remaining oil in mature fields is to be exploited to its fullest before the fields are closed down for good. This is also true for small petroleum reserves that have not been developed yet, and which have to be developed before existing infrastructure is brought to a halt because nearby maturing fields are shutting down. They also express that the reserve growth is dwindling so it is important to increase the funding to find and develop both new discoveries and development fields. In an article in www.politikkavisen.no[9] the Norwegian confederation of trade unions, the Federation of Norwegian Industries (FNI), the Ship-owners Association, and the Oil Industry Association together voice their concerns with the proposed funding for 2011 in the light of reduced possibilities for self-funding through big fields that covers the costs. This group has realized that in times where no big fields that can cover huge research and development costs are found, authority stimulation is important. This is a major concern to technology development since big fields sustain technology development, while small discoveries do not have the ability to finance technology development (Knut Aaneland, 2011). The finding of the Norvarg field (190 km offshore) is one example of this; the field is located further out into the sea than the Snow White field (140 km offshore) and today it is close to impossible to transport petroleum in pipelines over such distances since the technology and infrastructure that is needed is not yet developed. The Snow White field is in the forefront of what can be achieve when it comes to petroleum transport in pipeline over distances, and the Norvarg finding is both further offshore and too small to single-handedly finance required technology and infrastructure (Bente Nyland, 2011). The MPE has reservations to increase the amount to the level expressed in the OG21 strategy. They feel that the amount 600-800 million is a desired and almost a wishful amount the industry feel they need, and a sum that is very difficult to manage politically. The government each year have to decide how much money they can grant to the different assignments in the budget, which is an exercise in budget settlement where a relative fixed amount has to cover a lot of 'good causes'. It is easy to imagine that in situations where you have to choose between better elder care and better research the choice would be quite easy in the budget settlement process; both because of moral considerations and because you can grant financing to something that give immediate results. But in critical times to certain industry one can expect that good causes and social

[9] http://www.politikkavisen.no/www__Dolf__Dno/_Konkraft-Petroleumsforskningen-m-styrkes-betydelig.php

benefits may have to wait till next year because business opportunities are lost if investment are not done right away. Another concern of the MPE according to Reidar Müller (2011) is that they are not sure if the research environment is able to absorb such a huge lift in the funding, and they ask themselves; Are there enough researchers? Is there enough good projects? Reidar Müller (2011) also mention that it can be a problem with swift increases in governmental funding, that it will take time for research institutes and other research actors like the universities to adapt and increase their capacity to meet the increased funding. The ministry acknowledge that the governmental funding is very important, but only a small part of the total amount spent each year on research and development aimed at the petroleum industry, but at the same time they remind that the governmental funding triggers huge investments from the industry. In recent years Norway has had a period with only small discoveries which have influenced the contractors and the petroleum companies' ability to invest large amounts in research & development. The authorities should maybe have started increasing their funding some years back. The recent finding of the big Statoil operated Johan Sverdrup field in the North Sea is a quite pleasant 'surprise' to the industry in a time where one had written off the North Sea as matured, and in a time where recent findings have been few and small. This gives grounds for reassessing the NCS and the assessment of the North Sea. So far it can only be seen as a bonus that they have found petroleum in an area believed to be matured or full of small pockets of petroleum. Norway can only wish that this was not the last big field and hope for more big 'surprises' on Norwegian territory in the future as new exploration areas are being opened.

4.2.2.3 Different Perspectives - Authorities and Petroleum Companies

The operators at the NCS are naturally mostly concerned with investment in efforts that are relevant for fields they are operating and difficulties/needs they face there. According Reidar Müller (2011) "…this is an important challenge for the MPE, to find the areas where the companies do the job themselves, and the areas where the government can play an important role, and we are often concerned with the areas of long term research and to get more out of each field (IOR/EOR)". Müller (2011) gives one example; "If an oil company is considering testing some chemicals that is believed to increase the oil recovery in ... let's say the Brage field, and they find out that it would yield a negative net present value, they then wouldn't go ahead with the project. But we the authorities have a different perspective, and are more concerned with the potential in the project. If the technology seems promising and has potential use in other fields, the authorities will give a go ahead for the project even if it has a negative net present value". Thus one can say that the oil companies do not always implement projects that have economic or technical risks associated with them. In cases where the government find it to be socioeconomic reasonable to develop or implement technology, their funding can help start projects that the industry wouldn't have done otherwise. Müller (2011) further states that; "this is the role of the governmental funding, to spur socioeconomic research that is not perceived as profitable for the petroleum companies".

4.2.3 The Norwegian Petroleum Directorate

The NPD is a governmental specialist directorate and administrative body established in 1972 subordinate to the MPE. The paramount objective of the NPD is to contribute to creating the greatest possible values for society from the oil and gas activities by means of prudent resource management based on safety, emergency preparedness and safeguarding of the external environment (www.npd.no)[10]. The NPD also set frameworks by; stipulating regulations, follow-up of regulations, and making decisions in the area they have authority. At a conference in Bergen the twenty-third of October 2002, the former director general of NPD Gunnar Berge, stated that;"the regulations shall not be experienced as a straitjacket for the industry, but leave room for the innovation and creativity" (www.ptil.no)[11]. He follows up this statement with "I believe that the regulation of today provides the right framework conditions". Together with the MPE, the NPD is also responsible for the security of supplies. The NPD is not directly involved in the technology development process as they do not contribute with funds, research or development, but they work as a driving force for research & development, HSE matters, and implementation of technical solutions that can mitigate challenges related to their authority area. According to Bente Nyland (2011) this is according to their role not to be the owner of the process since their perspective is that; it is the industry in collaboration with the research and educational institutes that are the ones that should come up with solutions. The NPD can only point to certain issues and state that they think more can be done here and there". One example of where they have done this can be viewed in an article at www.aftenbladet.no[12] where Bente Nyland goes out against the petroleum companies and request bigger efforts in form of funding and long term planning in relation to

[10] http://www.npd.no/no/Om-OD/
[11] http://www.ptil.no/nyheter/regelverket-ingen-tvangstroeye-article763-24.html
[12] http://www.aftenbladet.no/energi/olje/Oljedirektoeren-refser-selskapene-1888403.html

IOR and EOR. The NPD challenges the industry in relation to certain issues they find important, and they go into direct dialog with the industry to find out what they are thinking, doing and are planning to do in the future in relation to these issues. In addition to this the NPD is part of different bodies with different functions related to petroleum research & development. With several small players and small discoveries at the NCS, coordinating of testing of new technology across the licenses will be even more important than before. Hence the NPD established a forum called FORCE in 1995 with a mission to stimulate industrial cooperation (www.force.org)[13] between petroleum companies and the authorities of Norway. The focus in this cooperative effort, except the obvious to increase cooperation, is to improved oil and gas recovery and improved exploration. The body currently consists of thirty five oil and gas companies that have agreed to look for opportunities to share the costs and results related to field pilots (white paper nr.28, 2010/2011, p. 64). The authorities will through FORCE continue to lift forward additional pilots, and together with key players at the NCS work for increased efforts related to testing of new technology. A cooperation contract is developed to make it easier to cooperate between licences under the Force organization (Bente Nyland, 2011).

4.2.4 The Petroleum Safety Authority Norway

Subordinate to the Ministry of Labour, the PSA has the regulatory responsibility for safety emergency preparedness, and the working environment in the petroleum sector. This responsibility was taken over from the NPD when PSA was created in 2004. The agency's regulatory authority was extended to cover safety emergency preparedness and the working environment in petroleum related plants and associated pipeline systems (www.ptil.no)[14]. The goal is that commitment to safety shall pay off. The master idea is that companies through a thorough and professional approach to HSE will avoid costs associated with accidents and adverse events such as repairs, production shutdowns, possibly higher insurance premiums, lost rates of revenue, loss of intellectual capital and the like. In addition to reducing costs, a commitment to HSE also directs revenues by contributing to increased reliability, robustness against undesirable events, greater flexibility, and increased efficiency by making the business less vulnerable. The PSA's efforts are illustrated by the statement of Gøril Tjetland (2011) stating that "the PSA is quite eager to push for adoption when it comes to implementation of

[13] http://www.force.org/About-FORCE/
[14] http://www.ptil.no/role-and-area-of-responsibility/category165.html

technology related to HSE". As they have a regulatory responsibility they also supervise that the laws and regulations set by the authorities related to the PSA's duties are followed. As with the NPD, the PSA also works as a driving force for research and development efforts that can improve the performance while they at the same time try to challenge the industry to do more within the PSA's authority area.

4.2.5 The Research Council of Norway

The RCN is a governmentally established council and strategic organ that is responsible for advocacy of Norway's research domestic and abroad by; manage research funding, distribute scholarships and give the government advice on research policy issues. In the RCN's document of statutes their purpose is described: "The RCN shall serve as a national strategic and executive body for research. The RCN is responsible for increasing the general knowledge base, and for helping to meet society's research needs by promoting basic and applied research as well as innovation. The RCN is promoting international research cooperation and serves as an advisory body to the authorities in matters concerning research policies" (RCN Statutes, 2001)[15]. The RCN has a formidable area to cover and comprises of four research divisions where one is the division for energy, resources, and the environment.

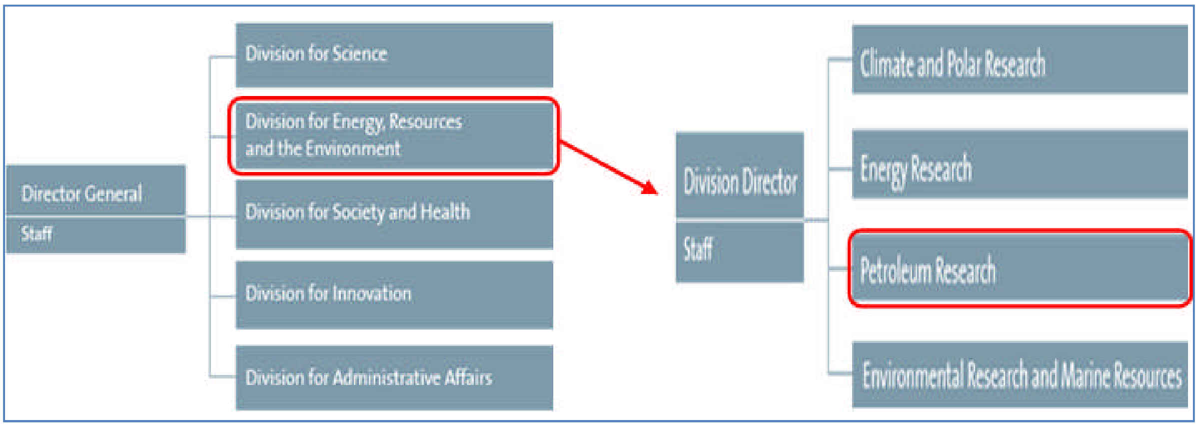


Figure 15 Organizational Chart of the RCN (Source: www.forskningsradet.no)[16]

The division is responsible for research and innovation targeting national and global challenges associated with energy, petroleum, climate, polar, environmental and marine

[15] http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3DRCNStatutes2011.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274468227525&ssbinary=true
[16] http://www.forskningsradet.no/en/Organisation/1138785841802

resources sectors. With so many target areas it has been necessary to divide the division into departments with their own specialized area; where one department has the sole responsibility for the petroleum sector. The department of petroleum is responsible for research, innovation and demonstration efforts in relation to petroleum. They work to achieve advances in expertise and technology that can improve the exploitation of Norwegian petroleum resources and enhance the competence of Norwegian players within the research community and petroleum industry alike. The petroleum department at the RCN has an extensive cooperation with; other ministries, the industry, and research groups nationally and internationally. Strategic, advisory and financing assignments related to the field are anchored here, and there are connections to the national strategic body OG21. The profile of the strategic petroleum research funded by the RCN is thus reflecting the precedence of the OG21 strategy, ensuring a coordinated effort between universities, research institutes and the petroleum industry.

4.2.5.1 Petroleum Programs and Other Petroleum Research Efforts

The RCN's role in technology development is for the most part related to funding, research, and administration of the programs they offer. The RCN channels most of their received petroleum research funding into few but big programs, and lesser amounts are given to a handful smaller projects and programs. The governmental funding is deposited to each project or program, and the industry can apply for the venture most relevant to them and receive the funding if they meet the program requirements. To be part of one of RCN's research & development programs companies have to apply for participation. The government had the long term goals and strategies in the back of their mind when they created these programs, so in order to get accepted in one of the programs one has to comply with the regulations and constraints present in the projects. The programs are aimed at issues that the government find important and that are anchored in the OG21 strategy, and where the industry would not necessarily have initiated on its own. Some programs calls for multiple participants amongst the actors of the industry, and it is the authority's wish that it could lead to more openness and cooperation within the industry. Below a few programs related to petroleum research are introduced.

PETROMAKS is the biggest petroleum program and was established in 2004 and works as an umbrella for most of the petroleum oriented research supported by RCN. Further the program is a key instrument to implement the national technology strategy - OG21. PETROMAKS covers basic research, applied research and technological development. Target groups are universities, colleges, institutes and businesses. The authorities have special responsibilities to stimulate to increased competence building in the shape of education, recruiting and basic research. The strategic basic research projects are mainly conducted at the universities. The educational institutes receive governmental funding for research through PETROMAKS. The program supports long-term capacity building, education and technological development, which are necessary elements in order to exploit the resources at the NCS optimally, while simultaneously developing competitiveness of businesses. PETROMAKS thematic areas for research and innovations are:

- Environmental technology for the future
- Exploration and reservoir characterization
- Enhanced recovery
- Cost effective drilling and intervention
- Integrated operations and real time reservoir management
- Subsea processing and transportation
- Deepwater, subsea and arctic production
- Gas technology
- Health, Safety and Environment

The program also supports the strengthening of alliances, creation of networks and facilitation of various types of cooperation with the world's leading scientific and technological institutions (www.forskningsradet.no)[17]. In the first five years of the program the focus has mainly been on exploration, realization of reserves and increased recovery rates. New signals from the authorities suggest more efforts towards energy efficiency and cleaner production, while at the same time keeping focus on better recovery rates (www.forskningsradet.no)[18]. In 2010 the program received about 231 million NOK in governmental financing, and 226 million NOK is allocated for 2011. According to Knut Aaneland (2011); "The program is for the most part user-driven and an arena for the contractors. In PETROMAKS projects it is

[17] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1226993690951&pagename=petromaks%2FHovedsidemal

[18] http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3D20101202PETROMAKSProgramplan.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274465306874&ssbinary=true

normally an oil company, a contractor and a research institute who are working together, but the applications normally are fronted by research institutes and contractors".

DEMO2000 was established in 1999 and is an initiative supported by the MPE in order to ensure long-term competitiveness of the petroleum industry and continued profitable development of the petroleum resources of the NCS. The program also aims to develop innovative Norwegian industrial products, systems and processes for the global offshore market (www.forskningradet.no)[19]. The program has three main goals:

1. New field development on the NCS through new, cost-effective technologies and implementation models
2. Increased security for completion within budget and schedule
3. New Norwegian industrial products for sale in a global market

Through demonstrations (pilot projects), new and cost-effective technologies can be qualified for use, and thus creating new products, new jobs, and new projects. Pilot projects involve close collaboration between suppliers, research institutions and oil companies, which in itself will develop a future-oriented, market-oriented expertise network (www.forskningradet.no)[20]. Most of the demonstration or piloting under DEMO2000 is done physically at the offshore fields or at onshore processing plants. In a cooperative effort like this participants share the costs involved which reduces the risks involved for all participants; and help qualify technology that would otherwise have been too risky for the participants to carry out alone. Initially the program was set to have around 100 million NOK each year at disposal to demonstration related projects (white paper nr. 2, 1998-1999), but no government have managed to achieve this. DEMO2000 have in fact been favoured with much less than initially set, only in 2006 (70 million NOK) and in 2010 (98 million NOK) has the program been close to this amount. The explanation of the 'high' amount in 2010 was due to fact that the program was favoured with an extra 50 million NOK from the governmental stimulus package related to the recession in 2008/2009. DEMO2000 is an important program but has only 46.7 million NOK to spend in 2011 on subsidising the industry for piloting projects. "The authorities funding of DEMO2000 is small change when you think of what is happening at Ormen Lange

[19]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296565509&pagename=demo2000%2FHovedsidemal
[20]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296565475&pagename=demo2000%2FHovedsidemal

at the moment, where they have a pilot running to test gas compression technology, where the investment is about 4.5 billion NOK" (Reidar Müller, 2011). Still the establishment of the DEMO2000 project give incentives for technology development, and according to their annual report (2008)[21] Demo2000 has between 1999 and 2008 handed out 2.5 billion NOK, which has released amounts four times that amount in form of investment from the industry. According to Runar Rugtvedt (2011) the typical distribution of costs in Demo2000 is that the government covers about 25 percent, contractors cover 25 percent, and the oil companies cover the remaining 50 percent". In June 2005 NIFU STEP was commissioned by the MPE to evaluate the DEMO 2000 program; which they found to be a success as it had reached its main objective. Hence the authorities decided to continue the program (NIFU STEP, rapport 7, 2005).

PETROSAM is a program that develops expertise on social issues as a basis for strategy and policy of the Norwegian government and business in the petroleum sector. Established in 2007 the program runs till 2012 and have a yearly budget of approximately 10 million NOK finances by the MPE and Statoil ASA. The primary objective of the PETROSAM program is to increase insight into petroleum activity in a societal context in order to provide the Norwegian petroleum authorities and petroleum industry with the best possible basis on which to devise policies and strategies. The program has two secondary objectives, one structural and one scientific. The structural objective of the program is to encourage the development of a stable, permanent and highly skilled Norwegian research environment in the field of social science-related petroleum research. The ambition is to develop strong communities that can compete internationally within the themes the program covers. The scientific objective of the programme is to generate knowledge in the following priority research areas (www.forskningsradet.no)[22]:

- Management of the Norwegian petroleum resources
- International development trends and the value of the Norwegian petroleum resources
- Developments in key petroleum provinces

[21]http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3D%C3%85rsrapportforDEMO20002008.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274461459047&ssbinary=true

[22]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296578138&pagename=petrosam%2FHovedsidemal

The programs shown above are the ones that receive the most governmental funding, but there are also minor programs and efforts related to petroleum research & development that also contribute to the process of innovative development, though with lesser governmental funding. Below a few programs and ventures related to innovation and technology development are mentioned:

- GASSMAKS seeks to increase the society's value creation from the gas industry by improving knowledge and economic development that lead to international competitiveness (www.forskningsradet.no)[23].
- The Ocean and the Coast program's main objective are to promote innovative research of high international quality of the marine environment. The PROOF research program, which is scheduled from 2006 till 2015, is part of the "Ocean and the Coast" program and examines the long-term effect of discharges from the petroleum sector.
- FORNY/FORNY2020, or 'Renew' directly translated, is a program which seeks to increase the value creation in Norway through commercialization of research results from governmentally funded research projects. The program is cooperation between the RCN and Innovation Norway. FORNY2020 is running from beginning of 2011 and is overlapping the previous project that has been in effect since 1995 (www.forskningsradet.no)[24], indicating that the program has been a success.
- Centres of Excellent Research (CER): The RCN has initiated a scheme called CER. The scheme will stimulate Norwegian research institutions to establish centres dedicated to long-term basic research of high international level, and aims to raise the quality of Norwegian research (www.forskningradet.no)[25].
- Centres for Research-based Innovation (CRI): The purpose of CRI is to build up and strengthen Norwegian research groups that work in close collaboration with partners from innovative industry and innovative public enterprises. The CRI arrangement promotes innovation by focusing on long-term research in close collaboration between research-intensive enterprises and prominent research groups. CRI develops skills at a

[23] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296770594&p=1228296770594&pagename=gassmaks%2FHovedsidemal
[24] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1253963921794&pagename=FORNY2020%2FHovedsidemal
[25] http://www.forskningsradet.no/servlet/Satellite?c=Page&pagename=sff%2FHovedsidemal&cid=1224067001825

high international level in areas that are important for innovation and value creation (www.forskningradet.no)[26].

Through these and other venues there is also a flow of significant amounts to petroleum research, and these funds are more an open competition where everyone competes for the same funds (Reidar Müller, 2011). These independent research venues are mainly financed through a research fund administrated by the RCN. With the establishment of these programs the government have build up infrastructure and given incentives that increases the money invested into research & technology development. These programs gives many good incentive to petroleum companies and contractors giving them opportunity to participate in programs directed at solving problems and develop technology they need in their operations, while at the same time the risk involved is reduced by sharing it with the other participants.

4.3 Petroleum Companies

Petroleum companies involved in the resource extraction at the NCS are big players in technology development as they are very dependent on resilient technology. The companies use a lot of technology in their daily operations and are for the most part concerned with technology that is relevant for fields they operates. The petroleum business and especially the offshore side of it, is a very capital intensive business and huge investments are necessary to find and extract the resources. Enhanced technology better than the previous one are always welcome since they save petroleum companies' time and money, and thus each year petroleum companies invest about 3 billion NOK for petroleum research & development (Petoro Annual Report, 2011, p. 32). Competition at the NCS has undergone major changes since the late 1990's, and after the merger between the Norwegian companies Statoil and Hydro's petroleum business, Statoil has dominated the NCS. Statoil with near 80 percent of total production at the NCS plays an important role and in research & development. In addition there are a number of large international players who have been active on the continental shelf for a long time and that have ownership interests in the fields there. Big international companies are important players who with their experience and capital bring new impulses to Norway, and participate and contribute in research & development here. Since 2000 there have been over fifty new companies at the NCS both Norwegian and

[26]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1224067021109&p=1224067021109&pagename=sfi%2FHovedsidemal

foreign, many of which are characterized as small, but still many have huge parent companies with significant financial strength backing them. In this thesis I have taken a closer look at two Norwegian oil companies, North Energy AS and Statoil ASA.

4.3.1 North Energy

The small oil company North Energy was established as recent as September 2007 as an initiative with roots in north of Norway. The company has an ownership composition where Norwegians own 65 percent of the company, UK 25 percent and miscellaneous Europe the rest 10 percent. North Energy has so far experienced a growth that is bigger than they expected, and with its initial northern-Norway funding this is quite impressive. In 2010 the company had equity of 480 million NOK, which is a huge increase since 2007 when they had 150 million NOK. Since the very beginning the company have built a portfolio of licenses in the Barents Sea, the Norwegian Sea and the North Sea, and by the end of 2010 they were part of 21 licenses at the NCS, but they only have operator responsibility on two of these licences. North Energy has four core values that shall characterize their business through their actions;

1. To be in front – innovative, alternatives, new ideas, solutions and technology, be the first to show the way
2. Competent – knowledge based on "state of the art", lead a good example
3. Bridge builder – to bring people together, point out the path, a preferred partner, focus and a facilitator
4. Fearless voice in the north – to be courageous enough to say what we believe is right and talk on behalf of the northern Norwegian community

North Energy has chosen to focus systematically on innovative solutions. Dense contact with the supplier industry and technological environments help the company optimize opportunities and plan for further research & development (North Energy annual report, 2010, p.6). North Energy's vision and objectives are based on that they can create a viable oil and gas industry in the north. Local effects and the environment are important aspects to them, and they are conscious of their role as manager of national resources and the environment. This is reflected in their outlook on development solutions. They state that they are searching for new technologies and innovative solutions that allow better utilization of petroleum resources, while they think long-term and seek the local impacts and ripple effects that are desired by those who will live with this in the future (www.northenergy.no)[27]. The company does not develop own technologies, and state that; “so far we use what others have developed, and that is good enough for us” (Knut Aaneland, 2011). North Energy does not have their own research facilities and he continues by saying; “We have to become quite a large company before we spend tens of millions on developing systems and technology ourselves. This is activities reserved the big companies”. Inge Carlsen (2011) supports this view by expressing that small oil companies are dependent on Joint Industrial Project’s (JIP’s), where several actors gather their research efforts, because alone they have limited funds available for research, but collectively they can achieve something. North Energy does not participate in any governmentally controlled programs or JIP’s, because they feel that it is too soon for this fresh company. They feel that the governmental programs are the contractors and big petroleum companies arena, but they receive many requests to be part of different projects from many different actors, but North Energy is at the moment holding back in fright of being involved in too many different activities and not being able to solve their core business properly (Knut Aaneland, 2011). At moment this small and still very young oil company has to concentrate all efforts at the exploration phase, that being seismic activity, drilling exploration wells, locating and mapping petroleum basins. Knut Aaneland (2011) emphasizes the importance of research & development efforts essential for the further development of the NCS. North Energy sometimes initiate research studies if there are topics they need to learn more about. E.g. exploring the potential development of a floating production unit/vessel (FPSO) -cluster off the coast of Helgeland carried out by the High North Centre at the University of Nordland. North Energy often uses local universities, Norut, Akvaplan-Niva, and others organizations to increase their knowledge. The University of Nordland have expertise in local value creation and ripple effects, but not on technology matters where they instead use e.g. the University College of Narvik as knowledge resource (Knut Aaneland, 2011). North Energy is as far as possible using companies with local ties to north of Norway for research & technology purposes and they cooperate with research institutes located in north of Norway as far as their partners competence reaches. Another character of North Energy’s innovative efforts is shown their willingness to think outside the box by using a combination of existing technology in a new and innovative way; to extract petroleum through a tunnel concept called “Eureka” (See figure 16 below). The Eureka concept consists of tunnels under the seabed leading to caverns where a land based drilling rig can be placed to

[27] http://northenergy.no/nb/var-virksomhet/utbyggingslosninger.html

drill wells to one or more fields. Petroleum can then be directed to an onshore plant via separate tunnels. Benefits of such a concept would greatly reduce drilling costs, avoiding interference with the fishing industry, avoiding harsh climate conditions, while at the same time eliminating the major risk factors such as discharges during drilling. The idea is not new and does not originate from North Energy as the idea was first discussed 20-30 years ago and was at the time called “PetroMine”. Back then the idea was generated in response to harsh climate and weather conditions, but was not adopted due to costs and technology constraints (Inge Carlsen, 2011). But the fact that North Energy is looking into such solutions for petroleum extraction confirms that the company has an innovative mode.

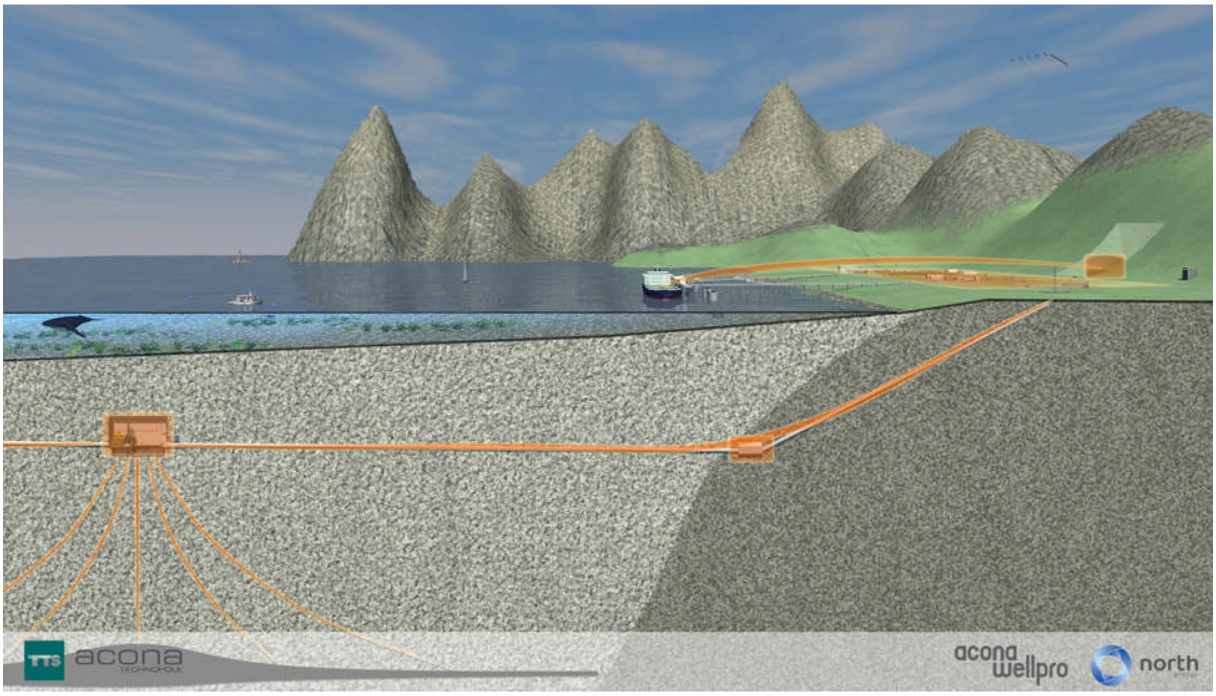


Figure 16 North Energy’s Tunnel Concept “Eureka” – (source: www.northenergy.no)[28]

The reason for initiating the Eureka concept came to life due to the report; integrated management of the marine environment in the Barents Sea and Lofoten (white paper nr. 8, 2005/2006). North Energy realized that there were many coastal areas that are relevant for petroleum extraction that would be opened in the near future. “The challenge is that these areas are vulnerable, so we were thinking that maybe there is a way to extract these resources without risking any spills into the sea” (Knut Aaneland, 2011). The company has together with Acona Wellpro done a comprehensive investigation of the possibilities and barriers of the Eureka concept and their conclusion is that the project is feasible. If the authorities decide to open up the areas of Lofoten and Vesterålen to commercial petroleum activities, North

[28] http://northenergy.no/en/our-business/development-solutions.html

Energy believe that the tunnel is a possible solution for these and other similar areas. According to Gøril Tjetland (2011) there has been a shift in the political views on the Lofoten and Vesterålen debate. In the white paper number 8 (2005/2006, p. 61) it was a treasured area that should be protected forever, but in the updated management plan of the Barents Sea and Lofoten (white paper nr. 10, 2010/2011, p. 67) the authorities have steered away from a zero-spill policy and total conservation. The political shift is that the authorities understand that the resources in these areas have to be extracted in the future, and that petroleum production have small emissions and need some wiggling room, if only a little. The biggest emission risks are connected to petroleum transportation and not petroleum production. The society seems to have the perspective that it is not possible with today's technology to extract these near costal resources at an acceptable risk and thus the petroleum industry need to follow this up by presenting new ideas and solutions that can reduce the risks even further. This is part of what North Energy has tried to do by looking into the opportunities that lies in the Eureka concept.

4.3.2 Statoil

Statoil was established in 1972 under the name "The Norwegian's States Oil company A/S" as a fully state owned corporation, and at the time had a number of political considerations to take throughout its business. The company grew rapidly which lead to the establishment of SDEA under the management of Statoil and its subsidiary company Petoro. Statoil could after this conduct its operations with more emphasis on business and less on politics and thus could behave more like a private company. Today the company operates on commercial terms as other private companies throughout the world, without having to take political considerations. Statoil is a very dominant player at the NCS in all phases of petroleum operations. The company held by the end of 2009 interests in 219 production licenses and was operator for 42 producing fields. The company operates fields that together make up about 80 percent of petroleum production at the NCS. Statoil is also likely to allocate about one-third of the remaining resources at the NCS (report from the Extraction Committee, 2010, p. 31). According to Cato Willie (2011), former chief researcher for Ideas and Innovation Management at Statoil; technology is of key importance to Statoil because technology is an enabler for business development in Statoil and they use approximately 825 million NOK each year on corporate research & development activities. Statoil is committed to research, technology and expertise to fulfil its ambition to become a stronger and internationally

competitive company (www.statoil.no)[29]. Thus Statoil's research is organized into different programs within the value chain, in addition specific business challenges related to the Gulf of Mexico and oil sands in Canada:

- **Exploration:** Generate technologies and knowledge that will create new opportunities and strengthen positions in key exploration areas
- **Increased Recovery:** Improved reservoir models, new production methods and new drilling and well solutions to reduce cost
- **New field development solutions:** Develop technology for cost-effective realization of the challenging oil and gas fields
- **Oil-Gas Value Chain:** Research is necessary for the facilities in operation
- **New Energy, Health, Environment and Safety:** New forms of energy with a focus on offshore wind and second generation bio fuels, safety, and Co2 storage
- **Gulf of Mexico:** Get the necessary technologies quickly and profitably
- **Extra Heavy Oil:** Energy-efficient and good manufacturing solutions for the oil sands in Canada, and other onshore facilities
- **Laboratory and Test Facilities:** Operating and developing laboratories and test facilities, including test centre at Mongstad

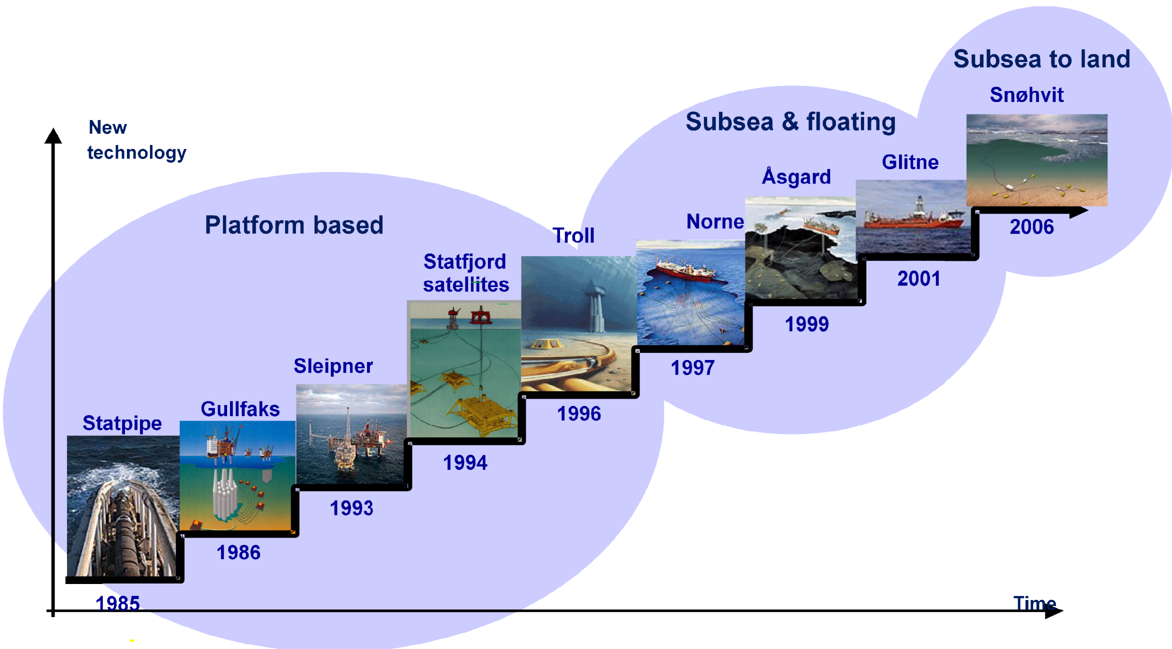


Figure 17 Field Developments at the NCS (Source: the Extraction Committee, 2010)

[29] http://www.statoil.com/no/technologyinnovation/researchinstatoil/Pages/default.aspx

Statoil has over the years been part of developing technology and the figure above illustrates how field development has changed operations over the last 25 years from platform based technologies, via subsea & floating to technology developments related to the Snow White field. In addition to the field development technology Statoil's focus on innovative development has given other results; Statoil operated fields have among the highest recovery rates in the world, and also the cleanest extraction of petroleum when it comes to emissions of green house gasses. In order to meet the needs for innovations it seems Statoil first try to take advantage of external expertise and thus they have developed an own separate website (www.innovate.statoil.com)[30] that function as a point of contact between Statoil and creative forces inherent in the industry. At this website contractors can read about Statoil's seven main technology areas that are of particular interest for development and innovation; exploration, reservoir, drilling and well, new field development, processing and refining, environmental and new/renewable energy. These are the same focus areas mentioned earlier except from the exclusion of the Gulf of Mexico, extra heavy oil, and laboratory operations. At the website there is also presented three concrete challenges that they need solved: Plug & Abandonment, Subsea Technology, and Sub-basalt exploration. The concrete problems are only on the webpage for a limited time and new challenges are presented from time to time. The website also provides opportunities to submit general ideas to all parts of their business and not only limited to Statoil's suggested areas.

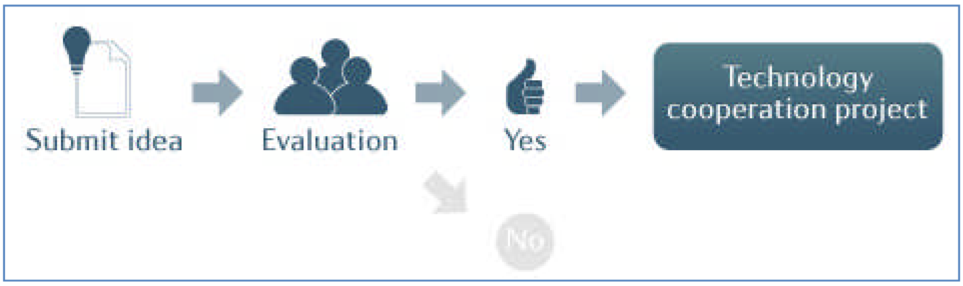


Figure 18 the Process of Teaming up with Statoil (Source: www.innovate.statoil.com)[31]

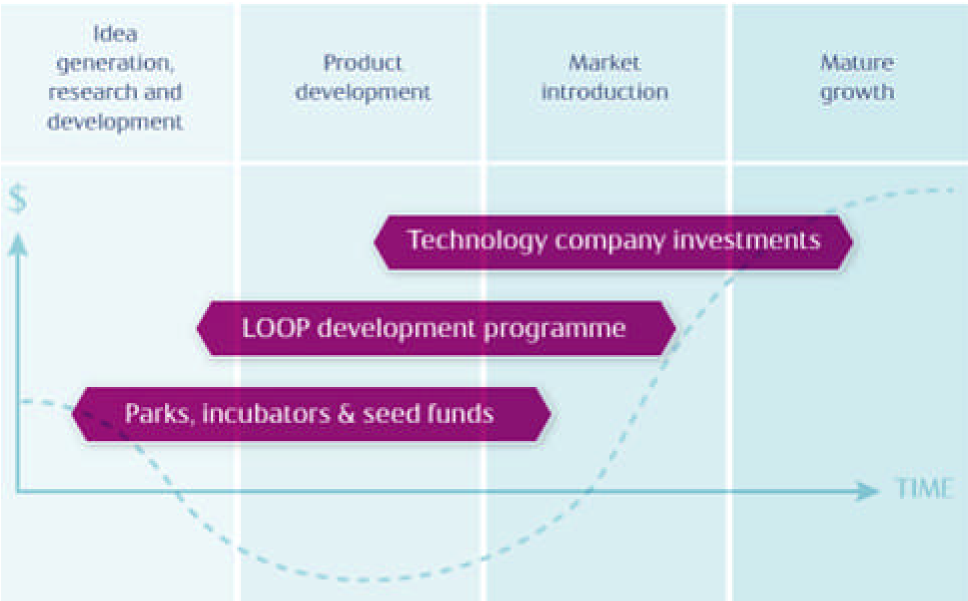
In the figure above the general path towards technology cooperation with Statoil is illustrated; Received ideas are evaluated and if approved they enter into a cooperation with the developer(s) of the idea. The petroleum company is interested in connecting with creative forces that might present new ideas or fresh perspectives to old and new challenges they face, and thus engages in projects with entrepreneurs and industrial companies in order to help new

[30] http://innovate.statoil.com/Pages/default.aspx
[31] https://innovate.statoil.com/_layouts/statoil.innovate/forms/ideasubmission.aspx

and emerging technologies reach the market. Once committed Statoil can offer participation in:

- LOOP, a program for product development (www.innovate.statoil.com)[32] which contributes with advice, financing, networking and potential pilot applications in technology development and verification projects
- Parks, Incubators and Seed Funds, which is their support of early-phase technology development. Statoil has ownership positions in several of these across Norway (See appendix 3).

In this way they offers funding for development projects, but at the same time they have also set a minimum demand that applicants need to show commitment by providing parts of the funding themselves. The petroleum company do not commit themselves to buy the end-product and the technology developer(s) has to compete for deliveries on equal terms with other developers. Statoil also invest in companies with unique technology and high growth potential in the petroleum and new/renewable energy sectors (www.innovate.statoil.com)[33]. The figure below sums up Statoil's technology efforts where their investments in development projects become more intense as the end-result is getting closer to the market. In their efforts they have particular focus on the development phase and the commercialisation phase of innovation. This includes detailed product development, prototyping, testing and verification, and market planning (www.innovate.statoil.com)[34].



[32] http://innovate.statoil.com/about/Documents/Fakta_LOOP.pdf
[33] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx
[34] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx

Figure 19 Statoil's technology efforts through external forces (Source: www.innovate.statoil.com)[35]

At Statoil they have a special unit within the division of technology & projects that has been given the responsibility for commercializing technology, and establish & develop industrial and commercial activities. Developed and successful technology has to be made available through the company's network of suppliers, and the technology often requires establishing new, entrepreneurial companies. The establishment of new companies is sometimes done for simplicity of the commercialization process; in addition Statoil has a strategy of not being a long-term investor. Thus the new company that now has the responsibility of the new technology that are (partly) owned by Statoil, will eventually be sold when the business is running smoothly. One example of this is the geophysics company EMGS that started out as a cooperation between Statoil and NGI. Said very short the EMGS's revolutionary technology involves sending electromagnetic waves into the ground in order to determine if there is petroleum present. The technology was developed and tested with positive results which led to the establishment of the EMGS company that later was sold to the investment fund Warburg Pinicus for some hundreds million NOK (www.forskning.no)[36]. For more examples of Statoil spin-offs see appendix 4.

Statoil have also its own research facility which was established and developed between 1991 and 1994 with a clear open innovative mindset (Cato Willie, 2009). The location at Stjørdal is not chosen coincidently as it has close proximity to the Norwegian University of Science and Technology (NTNU) in Trondheim. At Stjørdal Statoil's research efforts have been gathered, but exactly what research they do there is a layer that has not been possible to pierce in this study because Statoil chose not to participate in this study. This is a surprise as one of their main issues with the open innovative mindset was to avoid a closed technology fortress (Cato Willie, 2009). According to Inge Carlsen (2011) the petroleum companies can be quite arrogant as they feel they know best, but this can lead to a closed research environment. The research centre at Stjørdal is an example of this as there is little people know of what is going on there (Inge Carlsen, 2011). The information that has been gathered for this thesis has not given unambiguous indications of the activity at Stjørdal and thus I can only speculate in the data available. From the data I derive that Statoil as much as possible look outside their own organization to utilize creative forces in the industry, and beyond, to solve difficult challenges, thus stimulating innovative efforts and not so much starting their own

[35] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx
[36] http://www.forskning.no/artikler/2008/januar/1200389007.81

development endeavours. At the web-page that works as a contact point with creative forces; all but three of Statoil's prioritized research areas are highlighted there. Only the Gulf of Mexico, extra heavy oil, and laboratory operations are not mentioned there, thus one can be lead to believe that this is the activities that Statoil is conducting at their Stjørdal research centre. The reality is however more complex and they probably do much more there and especially research & development that they do not want to share with the public.

4.4 Contractors

The contractor industry makes a living out of selling their products to the petroleum industry, both technology products and services. They contribute directly in the process where they create products that later can be commercialized, creating value for the companies involved. The initial idea may either come from inside the contractor company, or they can be approached by a petroleum company that want their help in some respect. The FNI is a member association which organizes 2200 member companies (contractors) with 125.000 employees. They provides their members with legal advice related to being an employer and gives assistance in different issues mainly within; HSE, expertise and industry relationships (www.norskindustri.no)[37]. The FNI has several branch associations where one is the branch for oil and gas. According to Runar Rugtvedt (2011) "The FNI is a branch association that works toward stable and favourable working conditions in the petroleum sector in Norway. Our goal is that Norwegian contractors shall be in front when it comes to technology and development, and that they have products that are top-class, and that the products are attractive both at the NCS and the international market". Each year the board in the Oil and Gas branch at the FNI create a yearly action plan for research & technology development that works as the foundation for the next year's activity. This plan is then forwarded to the member companies in order to give incentives related to specific priority areas etc. The FNI stimulates their members to be creative, to think outside the box and to find new solutions (Runar Rugtvedt, 2011). The FNI hosts member meetings were the petroleum industry presents challenges they face, member companies inform about what they are developing and how they are cooperating with one and another, and the research sector presents what they are concerned with. At these meeting the opportunity to become more unified in their efforts are present. The FNI also works toward educational institutions as well. They arrange what they

[37] http://www.norskindustri.no/om-norsk-industri/kort-om-norsk-industri-article3058-73.html

call a ‘petroleum day’ at universities, where they use one day to discuss oil, gas and renewable energy with the teachers and students. They also have a program directed towards primary and secondary schools were they inform about the industry.

There are many contractors that works and deliver products to the petroleum industry at the NCS, both Norwegian and foreign. Schlumberger is a foreign company that operates in Norway, and in fact Schlumberger and their subsidiary Western Geco invest more in innovations & technology development at the NCS than the Norwegian government (Report, Petroleum Research Pays Off, 2005, p.12). The contractor industry have small margins and not so much funds to put into research & development in comparison to petroleum companies, but the FNI have noticed that more contractors are now setting aside higher amounts to technology development to be in front. The contractors use about 1 billion NOK each year on research and development (Petoro Annual Report, 2011, p. 32). The petroleum companies have quite good conditions at the NCS for developing technology in projects as they have a favourable tax regime, depreciation arrangements, return of cost etc. This has resulted in many projects that have naturally rubbed off to the contractor industry since the petroleum companies hires contractors to their projects. This is favourable for the contractors since they do not have the same advantageous tax position etc. as the petroleum companies. According to Runar Rugtvedt (2011) the contractors have intense collaboration in the process of innovative development with the rest of the stakeholders at the NCS. “In Norway we have developed clusters of expertise who have become very good in different technology areas. One example are the sub-sea cluster where 70 percent of the world market is run by three companies with their seat in Norway, with SMC in front, and Aker Solution and General Electric as second and third. There exists a drilling cluster in the south of Norway with EMC as an umbrella organization; this is a huge success as they export 90 percent of their technology. Another cluster is the called the Møre-cluster within the maritime oil and gas, where the Norwegian shipping environment has the most advanced and newest fleet built with the help of designers and ship yards located in Norway and who are amongst the biggest in the world” (Runar Rugtvedt, 2011). In addition to these already established clusters, the interview with North Energy gave information that indicates the potential of another cluster being developed with high expertise in Floating Production Storage Units (FPSO) at the coast of Helgeland.

4.5 Research Institutes

One of several key factors behind the creation of value that have taken place during the Norwegian petroleum era is the focus on petroleum related research & technology development and a willingness to learn. The competence built up over time is in many ways an inconspicuous but decisive factor in the Norwegian petroleum success. The Norwegian research environments that exist today have gradually built up competence and knowledge relevant to the NCS and the challenges the industry faces. Important research institutes that do petroleum related research & development are Rogaland research, Christian Michelsen Research, Institute for Energy Technique, SINTEF, the International Research Institute of Stavanger and Norwegian Geotechnical Institute whom all have their own speciality areas (report, Petroleum Research Pays Off, 2005, p. 16). In addition to these research institutes there are a lot of other efforts like CER and CRI that all contribute to the research and development efforts of technology at the NCS. This list is not by any mean exhaustive but only provides some examples of the research institutes that are working in this area.

SINTEF is another example of a research institute that also do petroleum research. SINTEF is Scandinavia's largest independent research group that create value through knowledge, research and innovation, and develops solutions, and technologies. The SINTEF Group comprises the SINTEF Foundation plus four limited companies and SINTEF Holding. One of the four limited companies are SINTEF Oil and Energy, that comprises of SINTEF Petroleum research limited and SINTEF Energy limited, that works with research along the whole value chain of petroleum products and sustainable energy systems (www.sintef.no)[38]. SINTEF petroleum research has built up their competence in finding resources, basin modelling, drilling, and reservoir recovery, thus for the most part in the upstream parts of the petroleum value chain. According to Inge Carlsen (2011) there are three ways research institutes get involved in technology developments at the NCS; first they can themselves produce ideas, preferably in collaboration with the petroleum industry, second they can apply for funding through the RCN, and third the industry might approach them with ideas where they want them to illuminate certain themes through research. One example from 2009 is when SINTEF conducted a quick study related to well-security on behalf of the NPD. This example, were the 'employer' is the authorities, is not very typical. Because as Inge Carlsen (2011) states; 90 percent of their research is directly financed by the industry, and only 3 percent comes from public funding to independent research, which he of course thinks is too little. The amount of

[38] http://www.sintef.no/Om-oss/Organisasjonskart/

independent funding is dependent on how big turnover the research institute had and the results of their research. SINTEF has formed partnerships with different stakeholders at the NCS, like NTNU and the University of Oslo. Personnel from NTNU collaborate in SINTEF projects, and SINTEF employees teach at the university. An extensive joint use of laboratories and equipment further characterise the collaboration between them (www.sintef.no)[39]. In order to secure a high level of expertise University collaboration has a high priority in the SINTEF group.

4.6 The Community

The last category of stakeholder is not as uniform as some of the other groups of stakeholders, as there are several and quite different sub-groups assembled within this term. Fishermen, local shop owners, environmental interest groups, animal-rights groups, non-profit organizations, etc. all fits into this group. The community as a stakeholder of the petroleum industry often express their opinions and in this context for the most part related to fear of consequences of further development of the petroleum industry. The biggest concerns for the community stakeholders are:

- Spills or leaks can destroy the environment and wild life/marine life
- Petroleum facilities onshore increases risks by that they handle hazardous chemicals/materials that can threaten water supplies, takes up industrial space, and pollutes the environment
- Offshore installations at sea often create conflict with another very important industry namely the fishing industry; local fishermen can no longer drive their boats where they want, while the petroleum activity might affect the fish population

In sum the community stakeholders view the petroleum industry with scepticism because their own interests are threatened or may get negatively affected by the petroleum activity in the future; either it is inhabitants who like to have a stroll at their nearby foreshore where an oil spill will result in loss of recreational opportunity, or local fishermen losing fish or fishing fields due to petroleum activities. For these reasons the community stakeholders tend to work against the development of the petroleum industry. The petroleum industry does not have the best reputation around the world when it comes to complying with community stakeholder's

[39] http://www.sintef.no/Om-oss/

point of view. So it is easy to understand how difficult it can be for these stakeholders to get their voices heard by an industry that is perceived as strong and difficult to influence and pierce through. The fear is based in the belief that petroleum companies only follow their own agenda and will not take any considerations unless pressured. To be able to pierce through petroleum companies, community stakeholders tend to organize themselves in order to be stronger and more visible. Only when people in communities around the world organize their efforts collectively they can hope that they are able to take a stand against big, strong, and strategic corporations. One example of these diverse stakeholders is independent non-profit organizations like Bellona, whom works to increase the ecological awareness in the community to prevent pollution and mitigate climate change that affects people's health and the environment. Another example is the political grass root organization 'Peoples Action for an Oil Free Lofoten and Vesterålen' (www.folkeaksjonen.no)[40] where people with same viewpoints come together to work towards a common goal; to fight for a permanent petroleum-free area offshore Lofoten and Vesterålen. In order to get their opinions and perspectives communicated these stakeholders typically try to exploit the networks that they have and they are in constant dialog with other organizations, businesses, media, researchers and politicians. Public relations and information exchange is thus important and the interest-groups are also publishing their own technical reports, notes and magazines. By expressing their opinions through their communication channels the community stakeholders tries to achieve as much influence as possible over people and decisions that is to be taken. In some extreme cases the community is able to exert such a strong pressure on a petroleum company that it is forced to respond and change in some respect. One example of this is the Esso consumer boycott in 2001-2003 that changed the shareholders opinions, and in the end the company's perspective on climate change (Gueterbock, 2004). The Norwegian example is seen in the debate of petroleum operations in the areas of Lofoten and Vesterålen were the community has been part of making it a political issue, which has resulted in postponement of further petroleum activities in these areas.

In this way they are been able to have some influence amongst the other stakeholders and can not be taken for granted. There are of course stakeholders in the community group that work together with the petroleum industry, because they recognize the positive impact the settlement of the industry bring with it. The freshest example of this in Norway is found in Hammerfest where all inhabitants embraces the industry, an industry which has made the city

[40] http://www.folkeaksjonen.no

of Hammerfest grow and that have added needed capital to the region. In Norway the attention for the community stakeholders has not been very imminent, mostly because the petroleum installations are far out in the sea and not noticeable in peoples everyday lives, except maybe in few parts of Norway. Further there have been few accidents in Norway and no big ones that have impacted the nature or marine/wild life irrecoverable. Not to say that these stakeholders haven't made protests etc, or been taken into consideration, only that this is becoming a more important aspect of the petroleum industry at the NCS and to the rest of the world's industries for that matter. As the petroleum industry is moving further north the community stakeholders 'cause' grows stronger since some of the present and coming fields will be located in vulnerable and near coastal areas. Recent spills like the "Deep Horizon" accident in the Mexico Gulf together with the increasing global awareness regarding climate changes makes this groups' presence meaningful, relevant and important.

4.7 The Process of Innovative Development

4.7.1 A Need or Recognition of a Problem

There are several reasons why an innovative process is kick-started and innovative efforts are set in motion at the NCS. From the very beginning the companies that operate at the NCS have literally been thrown into the deep end as the offshore environment is hostile and the resources hard to reach. Hence innovativeness has always been necessary to access resources at the NCS. "In Norway we are operating at deeper waters, we have more pressure, higher temperatures, more difficult drilling conditions, thus it is quite typical that innovative projects are initiated as a result of the huge challenges at the NCS. One example of this is the Ormen Lange field where they now are running a pilot on gas compression. The Ormen Lange field and many with it are experiencing lower pressure in the reservoir which leads to lower production. As the reservoirs are maturing and production has reached the tale, they need to continue developing the field to keep the production as high as possible and as long as possible" (Runar Rugtvedt, 2011). He further mentions challenges related to new findings as another generator for innovativeness. The harsh conditions in the seas outside Norway and the current profile of the NCS have naturally lead to higher costs, which is an attribute associated with the NCS; the extraction costs there are much higher than other places in the world e.g. the Middle East. Thus research & technology development that contribute to cost reductions are always very welcome. "The industry is very cost conscious because of the huge investments that is required, so research that is cost reducing, effective, and cheap have the highest focus in petroleum companies" (Inge Carlsen, 2011). Petroleum companies are always looking for new and more effective ways to do their operations like IOR/EOR, more effective drilling, cost reduction and acquiring licences. According to Inge Carlsen (2011) "...in the acquiring of licenses the companies are measured by their technology and what they are capable of accomplishing". Technology development may also be brought about by demands and regulations from the authorities; safety and environmental regulations and other provisions and influences. New ideas for innovations can in theory come from any stakeholder of the NCS; the petroleum companies, contractors, government, universities and research institutions. The contractors are in close contact with the petroleum industry and knows it well, and with this knowledge contractors can sometimes produce own ideas for technology research & development projects that can help mitigate the challenges the petroleum industry faces. But according to my respondents it is quite rare that it happens this way because contractors, or other stakeholders, are normally approached by a petroleum company that hires them for a contracted job. This is confirmed by Bente Nyland (2011) who states that; "the petroleum companies contact the contractors and the contractors do not do much unless the petroleum companies hire them". Historically the contractors have had small margins and not so many resources available to put into research & development, but according to Runar Rugtvedt (2011) more contractor stakeholders put aside money for research & development and use these money to develop their products and services. Contractors are almost always dependent on the goodwill of a petroleum company for demonstration, and this acts as a barrier to more research & development of technology. Research institutes tries to come up with own ideas for good research & development efforts, and often in collaboration with the petroleum companies. Research institutes may also get involved by applying participating in authority programs and recieve funding for research that way, or applying for the limited amount set aside for independent research. But according to Inge Carlsen (2011) there is too little independent research funds to apply for. SINTEF only have 3 percent of their funds to use on independent research where they decide themselves the scope. There is no reason to believe that the situation is different in any of the other petroleum related research institutes/divisions in Norway. In practise at this stage, before the 'go ahead' has been given for innovative endeavours, the community may highlight technology that is more environmental friendly or they can highlight problem areas or risk areas that need improvement and voice their concerns over outdated technology that is in use etc. Bellona has such gravity that they take part in governmental hearings and hence have a clear path to express their opinion before any major decisions are taken, and thus have some influence on political decision processes. As the community is standing on the outside, so to speak, and is not participating directly in innovative development processes they have were few options other than expressing their opinion and spreading their message to make their potential influence greater. In this way they can manage to create a strong external pressure so that their viewpoints are considered in the decisions processes. Besides this there is no other action they can take to on their own to kick start, or stop, an innovative process in relation to the petroleum industry.

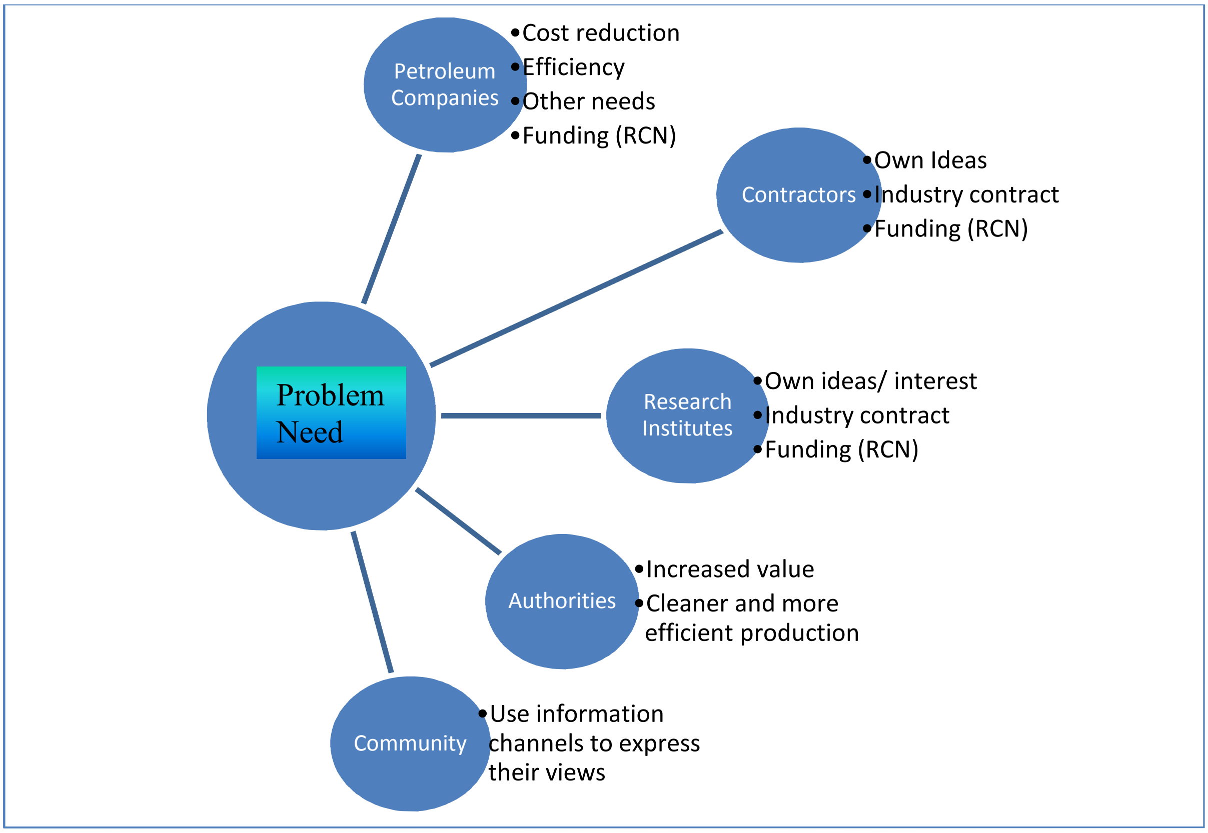


Figure 20 First Stage in the Process of Innovative Development with Stakeholder Entrance

The figure above tries to sum up the entrances and perspectives each stakeholder have to entering a innovative development process. The big bubble is representing the first stage in the process and the different stakeholders is presented by the smaller bubbles, while each stakeholders possible entrances is put in bullpoints.

competitive company (www.statoil.no)[29]. Thus Statoil's research is organized into different programs within the value chain, in addition specific business challenges related to the Gulf of Mexico and oil sands in Canada:

- **Exploration:** Generate technologies and knowledge that will create new opportunities and strengthen positions in key exploration areas
- **Increased Recovery:** Improved reservoir models, new production methods and new drilling and well solutions to reduce cost
- **New field development solutions:** Develop technology for cost-effective realization of the challenging oil and gas fields
- **Oil-Gas Value Chain:** Research is necessary for the facilities in operation
- **New Energy, Health, Environment and Safety:** New forms of energy with a focus on offshore wind and second generation bio fuels, safety, and Co2 storage
- **Gulf of Mexico:** Get the necessary technologies quickly and profitably
- **Extra Heavy Oil:** Energy-efficient and good manufacturing solutions for the oil sands in Canada, and other onshore facilities
- **Laboratory and Test Facilities:** Operating and developing laboratories and test facilities, including test centre at Mongstad

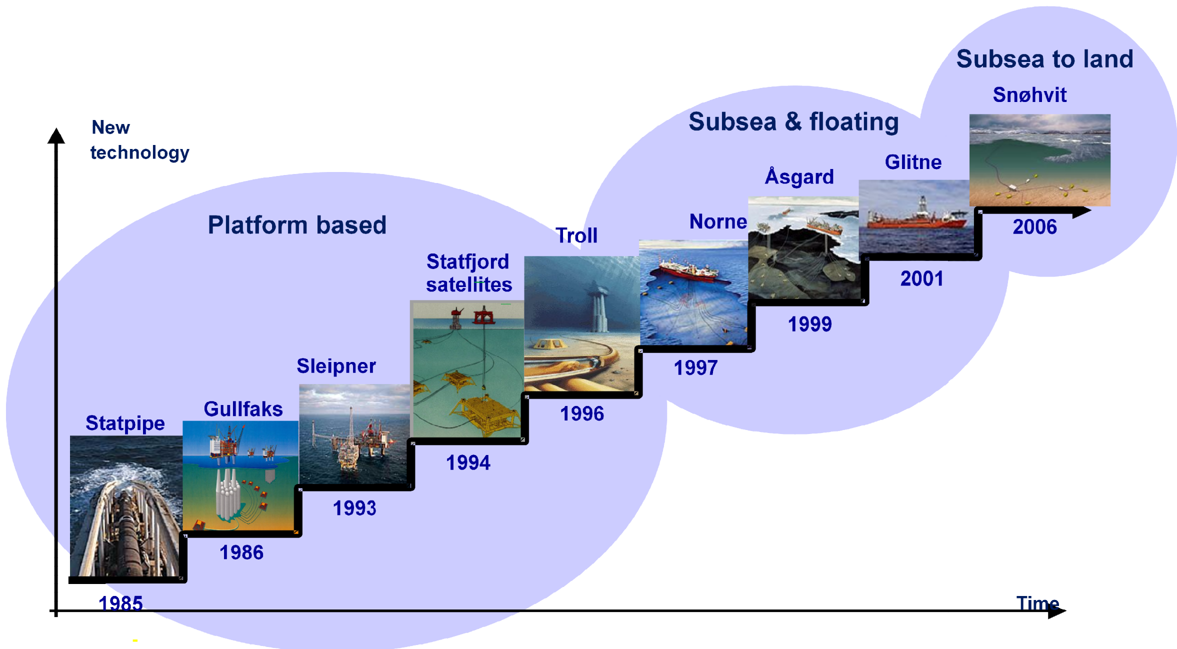


Figure 17 Field Developments at the NCS (Source: the Extraction Committee, 2010)

[29] http://www.statoil.com/no/technologyinnovation/researchinstatoil/Pages/default.aspx

Qualification carried out under the governmental program DEMO2000 and under the auspices of petroleum companies in collaboration with their partners are done physically onshore and at offshore fields. “The qualification of technology is about the companies testing and re-testing a component in order to be sure that the component works under right conditions, because if something fails or is destroyed after implementation at a field the costs involved are that much higher. The requirements for qualification are for the most part set by the petroleum companies to the contractors who develop the technology component. The approval is only done when the petroleum company is absolutely sure that the component works properly and under the right conditions” (Knut Aaneland, 2011). This kind of testing of technology physically at offshore fields requires the goodwill of a petroleum company, and is a collaborative effort between petroleum companies and their partner(s). According to Reidar Müller (2011) one thing they have often heard from the industry is that; “it is challenging to qualify enough new technology at the NCS at the moment. Statoil feel they do enough and have a lot of pilots, but others feel they are not doing enough”. Gøril Tjetland (2011) has the same viewpoint; “the challenge seems to be qualification and implementation of new technology”. Knut Aaneland (2011) states that; “it is imperative that we do not come to a point where the contractors develop something, and when they have a prototype that is no petroleum company that is willing to spend time or money on qualifying it. But so far at the NCS we have had big international petroleum companies that are willing to spend time and money in developing new technology and qualifying it”. The profile of the NCS has also played a role since few new big explorations have been made and developments of existing fields are low. This hinders both development and qualification as there aren’t any big fields like Ormen Lange that can cover the costs related these tasks. A new big discovery like Johan Sverdrup gives hope of more similar findings, since field of this size, and bigger, yields economic power that allows for development and qualification of technology.

4.7.4 Commercialization of Technology

When the innovation is through the qualification stage and has proven that it function according to specifications it is time to commercialize it, make it known, make it available as a product or service and win over potential end users. This is done by showing the products results from testing regarding quality and functionality to as many potential end-users as possible. In Statoil they have a designated unit that has the responsibility for commercializing technology and establish and develop industrial and commercial activities. Statoil have in the figure below shown the important aspects and things to think through in the commercialization process the way they see it.

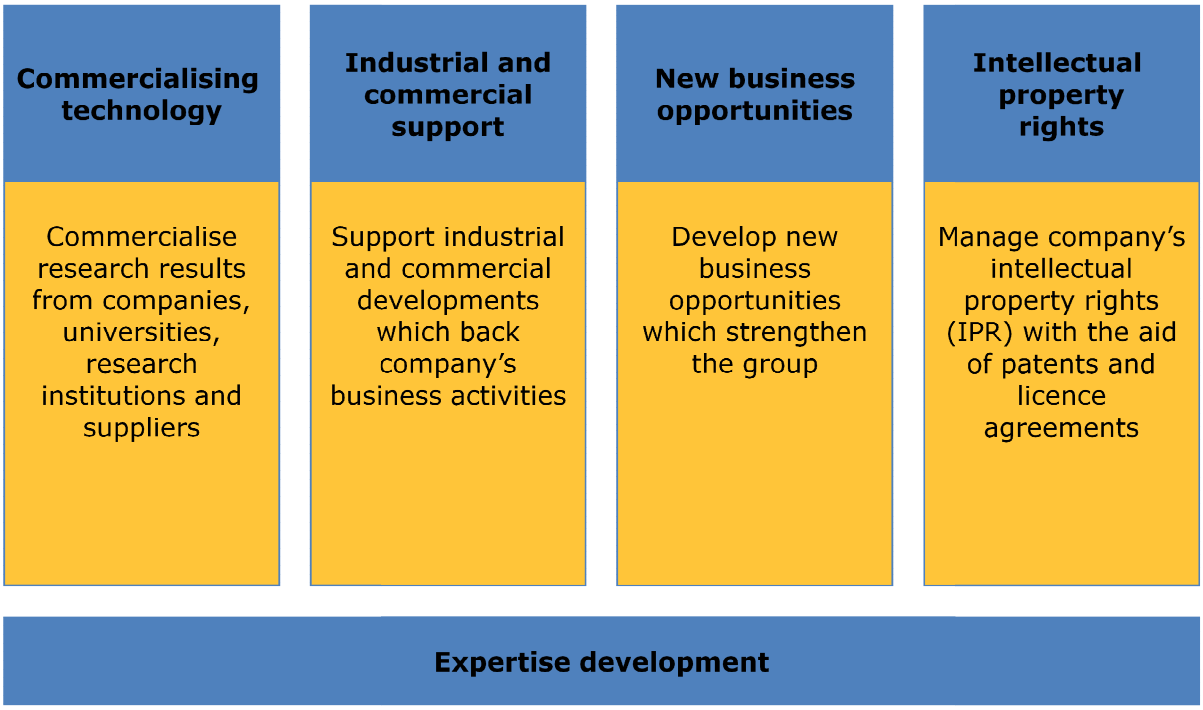


Figure 21 Cornerstones in the Commercialization Process (Source: Cato Willie (2011)

The first thing one has to do is to use the network you have to make the product or service known and available which can be done at exhibitions, trade shows, industrial arrangements, media, etc. The goal is to advertise the innovation by to make their product/service well known for its application and benefits and to receive support within the industry. Another important aspect that should be considered is if the technology should be commercialized through the existing company (companies) or if the product should be separated and commercialized through a newly established company. Often it is more functional to separate the innovation into its own company. It is important to think of patent rights before the product is released onto the market because you want to protect and manage the ownership of the innovation to realize maximum value, securing income to cover costs and profits. Another reason to think about patent is that during the patented period no one can sell copies of your product, thus maximizing revenue. "The Norwegian subsea contractors are very thorough when it comes to take out patent rights to make sure that no one else is producing their products as their own" (Knut Aaneland, 2011).

4.7.5 Diffusion and adoption of innovations

When I started this course I had a presumptive assumption that petroleum companies that possessed a ground breaking piece of technology would keep this a secret to give them a competitive advantage over their competitors. This assumption is for the most part wrong when it comes to the petroleum industry. The upstream business is divided into two phases the exploration phase and the production/operation phase, and there are some differences in these two phases when it comes to motivation to share knowledge between competitors. “In the phases of production, drilling, field development and well safety the industry have recognised that they benefit from sharing their experiences. And according to Bente Nyland (2011) will those who have developed an innovation see the business potential in it and thus want to spread the innovation to as many as possible. In the exploration phase there is much more secrecy related to how to interpret seismic data, and the big oil companies do a lot of their own research which they do not share with others” (Inge Carlsen, 2011). This is confirmed by Bente Nyland (2011) who states; “The biggest competition between petroleum companies at NCS is in the exploration phase when you compete about licences. In this phase it is important to have a competitive edge over you competitors, and in such an environment it is almost impossible to have an open and sharing research environment”. She further states that the competitive edge is knowledge. In order to interpret the data (seismic and other) the analysts use computer programs, modelling systems, and other analytical tools which often are made inside the company. Hence this kind of knowledge is kept secret as it can give a competitive advantage in the acquiring of licences and tenders. That is only if the knowledge they possess give them better understanding of data and reservoirs than their competitors. Reidar Müller (2011) also confirm this when he stated; “technology for exploration like seismic and other ways to acquire data is open and available to everyone, but the way they work with and interpret the seismic data is kept as well guarded secrets”. Thus there is a distinction in the level of secrecy in the exploration phase, between technology for acquiring data, and knowledge and creation of programs that interpret the exploration data. Apart from this my understanding is that there is little secrecy or competition related to technologies in the petroleum industry in Norway, and according to Inge Carlsen (2011) technology spreads fast after it has proven its capability and become qualified. “For contractors the competition is more related to the phases of field operations and field development where they compete for tenders” (Bente Nyland, 2011). Some companies may have technology that they do not want to share with other, but in such cases ‘lookalike’ innovations will soon pop up in the market. Most companies that develop a product at the NCS do not only consider operators in Norway as potential clients, rather most producers are interested in exporting their components throughout the world. The Norwegian authorities also see export of technology as a target in their OG21 strategy. To be able to accomplish this, the developer has to deliver quality in order to be able to compete internationally. Considering the different technology clusters that have developed in Norway and whom are in top of their class worldwide indications that technology developing stakeholders of the NCS have not had problems to compete on the international market, rather they have thrived and grown.

4.8 Technology requirements at the NCS

In Norway there are no specific requirements to what technology to use in petroleum operations, as the authorities only set so called functional demands to companies that operate at the NCS. Functional demands are requirements of what the companies have to do and be able to do at the areas they are awarded without any specified technology specifications. According to Bente Nyland (2011) "There are no requirements related to technology in the exploration phase, only to competence and exploration strategy. In the extraction phase there are only requirements for safe and optimal solutions. In certain areas of field development there are demands to usage of the best technical solutions available (BAT), but in general we only have expectations to usage of the best technical solutions available, and we also 'reward' such utilization". When a company have found petroleum and the field is to be developed they need to apply for operator rights by showing how they want to develop the field, operate it, abandon it and what consequences this has on the environment. Hence those who have ambitions to be awarded a license at the NCS and operate there need to apply through a Plan for Development and Operations of petroleum deposits (PDO). In response to these applications the authorities thus have a possibility to use their influence and set some requirements to the applicants; like that they want the operator to implement a purification element, or inject CO2 for IOR, power from onshore, etc. Later Plan for Installation and Operation (PIO) gives permission for installation and operation of facilities – often intended for transport of petroleum (guidelines for PDO and PIO, 2010). The government receives many applications for each field and approve the application with the most optimal and safe solution. No too specific requirements only functional demands. According to Gøril Tjetland (2011) setting demands in these application rounds has not been very successful as the government is not using its full power to persuade the operators. Another requirement under the functional demands are Best Available Technology (BAT) which originates from an EU directive (www.regjeringen.no)[41] and according to Runar Rugtvedt (2011) "The BAT arrangement sets demands that everything that is going to be used shall meet the safety regulations, be in acceptable condition, and have proper functionality". This regulation enables petroleum companies to choose technologies and procedures that they see fit for the operations they are in charge of, but at the same time this entails more responsibility as they are held accountable for their actions and choices. This is supported by Bente Nyland (2011) who states that; "The authorities do not have any competence to determine what technology that is best to utilize, the companies are made responsible for the implementations of technology and other solutions they chose in their petroleum activity. In relations to e.g. implementation or changes, the authorities only check if the proposed solution is safe and if it looks like the optimal solution. But they never say that to run this operation you need to use this or that technology". According to Gøril Tjetland; "The Norwegian Veritas (DNV) has made a way to sort technologies in relation to BAT. The scale goes from 1 which is well tested and used technology, to 4 which is new and untested technology. The problem with this scale is that it does not take into account the potential of the technology. One technology that is not so well tested may get a bad score even though the potential may be increased performance, improved safety and fewer spills".

Most of the technologies that becomes diffused are related to challenges in fields at the NCS, and are the same challenges that triggered the innovative process in the first place; efficiency, cost reduction, IOR/EOR, high pressure, etc. Petroleum companies that operates at the NCS are very rational in their decisions and choices and is seen as quite conservative, thus when there are several solutions to one challenge petroleum companies tend to choose the cheapest solution (Inge Carlsen, 2011). The authorities can ask for assessments if they suspect inappropriate operations, but they will only take direct actions in situations where there is obvious waste of resources. This is very demanding because of high complexity and many parts (Bente Nyland, 2011). According to Runar Rugtvedt (2011) it is very good that the BAT arrangement is written down in the framework, as he explains; "In some fields where the profit margin is not the best there are examples where BAT is not used because of cost and price issues. So it is good for Norway to have this option to make sure that not too discarded technology is used". This means that in situations where petroleum companies' make use of cheap components which might create dangerous situations or impact the total potential of the

[41] http://www.regjeringen.no/nb/dep/md/dok/rapporter_planer/rapporter/2007/naringslivets-miljoansvar/-5/-3/-2.html?id=477932

reservoir due to bad quality; the authorities can use the BAT agreement and request that the petroleum companies choose a different technological solution that is more optimal.

4.9 Summary Empirical Data

Through an innovative process stakeholders are developing technology at the NCS. The main stakeholders of technology development at the NCS have been presented; with their role, function, and contribution to the development process. The authority's main framework for the petroleum industry has been described and we have seen that there seems to be a healthy environment for innovative efforts to take place in Norway. Petroleum companies' challenges trigger a need for technology to be developed, and petroleum companies also decide which technologies that are successfully adopted and diffused. Qualification of technology is very important in Norway follows, and can be considered its own phase in technology development at the NCS. Data collected in this study suggests that qualification is slowed down and increased investment to qualification/demonstration efforts is requested. In the end of this chapter we have seen that the Norwegian authorities do not have specific requirement to which technologies to utilize or develop, but rather places the responsibility, to choose appropriate technologies, onto the petroleum companies. Petroleum companies tend to chose technologies that are saving costs and increasing efficiency.

5. Analysis

5.1 The Institutionalized Framework

In the Norwegian petroleum industry there are a few major factors that are part of setting the framework for the petroleum industry and technology development, the authority's regulations, the market itself, and matters related to education. The theory of institutional isomorphism is about how and why organizations within the same organizational field change in formal structure, organizational culture, goals, program, without becoming more effective. Most organizations do not seek changes that doesn't improve their business in some way, thus such changes are often related to external pressure and forced changes. The term 'organizational field' relates to the NCS as stakeholders within the same stakeholder group that all belong to the same organizational field. Common for such changes is that they apply to all stakeholders and thus contributes to make the industry more uniform. It is not necessarily a bad thing that the petroleum industry is uniform if things are done correctly. Below isomorphic institutionalization found in the empirical data-set are presented.

5.1.1 Coercive

Because of the values involved and the strategic importance of energy, the petroleum industry in Norway is highly structured by the authority's comprehensive and precautionary framework; in form of laws, regulations, strategies, and other contstraits and provisions that the industry have to comply with. It is only natural that a host country use these measures to protect their rights and their environment and it is in this way Norway makes sure that their standards are utilized in petroleum operations on Norwegian soil, and that they receive value for their resources. This is examples of coercive isomorphism where the stakeholders at the NCS have to adapt and adjust the authorities demands to be allowed access to the NCS. Together with the infrastructure (research & educational facilities, testing facilities, programs, other regulated industries, governmentally owned agencies, etc.) the provisions can be viewed upon as an institutionalized framework that has been developed over the years. Too stringent regulations can lead to too much homogenity amongst stakeholders and can prevent innovativeness. The reason for this is that similar organizations think and act alike which can lead to insufficient pionering and fresh ideas, further too much regulation can result in international companies moving their research & development efforts away from Norway to another country with less regulations. It does however seems like Norway have found the right balance between their regulations and BAT/functional demands that allows the petroleum industry to operate in a way they find acceptable and profitable. The result is that Norway is a technology hub and many big international petroleum companies and contractors have made sure that they have a strong research & development unit present in Norway because of the innovative environment there. Examples of a pioneering technology that is being developed is the extremely costy pilot projects on subsea compression being qualified for Åsgard and Ormen Lange, - where the upside is so big that the petroleum companies are willing to participate in hugly costly and risky projects. The reason that makes petroleum companies able to take such risks is that the authorities have incorporated incentives for innovative efforts into its regulations; through its taxation system, financial agreements, research programs, and tax scheme agreement for innovation, etc. Another reason is that functional demands provide freedom to operators at the NCS and works as counterbalance to many other provisions. The authorities have further shown ability and willingness to adjust to changing conditions when they saw a need for smaller companies that could handle smaller or matured/abandoned fields, they made arrangements so that these companies were able to enter the NCS on more competitive terms. Previously only large companies with economic of scale were allowed/able to operate in Norway, but the authorities facilitating effort for smaller companies have worked against too much homogeneity at the NCS in that a much wider variety of companies are involved in the industry now.

5.1.2 Mimetic

In the petroleum industry and especially in harsh operational areas, uncertainty is an everyday presence that is difficult to avoid. Uncertainty can be related to almost everything in a technology development project at the NCS; weather, time, funding, costs, security, technology, etc. According to the theory a way to reduce and avoid uncertainty is by benchmarking routines, technology, processes, etc, that other have adopted and are using with good results. This is a form of mimetic isomorphism that is usual in most industries and especially in industries with a high level of uncertainty, like the petroleum industry in Norway. One can say that this is an institutionalized process/action that is used by stakeholders at the NCS when uncertainty is high. Benchmarking will save costs related to research & development and solutions that have demonstrated capability will dramatically reduce uncertainty, but at the same time it will contribute to more similarity in that they are using same technologies/procedures/standards. North Energy confirmed that they are benchmarking technology rather than developing their own, while Statoil on the other hand do own research but for the most part hire others to do the necessary technology development. Mimetic isomorphism is thus very much present at the NCS in that stakeholders benchmark each other's technologies and standards that have already proven its quality through usage. Big petroleum companies with operating rights on big petroleum fields are in a position where they can develop new solutions, while smaller companies are more inclined to benchmarking. In most cases however it is more appropriate to benchmark someone else's solution rather than spending money rediscovering the wheel.

5.1.3 Normative

Highly structured industries will normally have quite uniform institutionalized stakeholders because of many regulations and limitations, and this is also true for the NCS as we have already seen. Another reason for uniformity of the industry is that inside each stakeholder company that operates at the NCS there are employees and specialized personnel that have similar education, experiences, and that attend the same networks, workshops, etc. It is therefore reasonable to assume that they tend to think and act similar. This is a form of normative isomorphism which also causes stakeholders at the NCS to become similar to each other. The companies at the NCS chose from the same population of applicants when they hire employees, and thus there is little difference between how managers and specialized personnel solve tasks in each their organizations, adjusted for small discrepancies of personality and chance. Normative change at the NCS is by the author considered to constitute a small but inevitable factor as a result of the educational system, and it's not necessarily negative that "everybody" is solving similar problems in a uniform way on the contrary it may be an advantage if the execution is correct. And the empirical chapter provided information suggesting that execution at the NCS is very good.

5.2 Stakeholder Relations

As mentioned in the theoretical chapter the basic idea of stakeholder theory is that organizations that want to be successful and achieve their goals (create value to investors) need to know all their stakeholders and these stakeholders relationship and interest to their business. At the NCS the organizational field involves all actors who in some aspect are connected to the industry, being contractors, suppliers, electricians, government, national oil companies, international oil companies, fishermen, etc. The empirical data show that the stakeholder of the Norwegian petroleum industry, and thus stakeholders of the technology development processes, seems to be very aware of each other's presence, what they do, and how this can impact their own corporation. Both petroleum companies and contractors make use of universities and research institutes for basic research, and as long as the necessary knowledge is there both Statoil and North Energy use local forces to the full extent and in that way part of making ripple-effects into the community. The Norwegian petroleum industry is of such a character that it often requires cooperation in huge operations to make the resources available in a way that is commercial viable. The harsh conditions have stimulated cooperation and the authorities facilitate for increased cooperation through the FORCE initiative, DEMO2000 and other schemes. For small and medium sized companies the cooperation through JIP's are very important to make them compatible, but even big petroleum countries depends on cooperation with other stakeholders. Extensive cooperation has resulted in technology-clusters that are doing exceptionally well both domestically and internationally. One such cluster is the drilling-cluster in the south with EMC Node as an umbrella organization which holds around fifty drilling related companies. Other clusters are subsea, seismic, and maritime vessels where Norwegian contractors have world class products and services to offer. Thus the empirical data indicates a high level of cooperation and communication amongst stakeholders of the NCS when it comes to technology development, and that they utilize each other's expertise often.

Both the authorities and the community observe petroleum companies and partners in their operations and will try to influence them if they can. The community as a stakeholder is different from the rest in that they do not participate in the innovative process but actively work to make their opinions taken into consideration, and is thus standing on the outside with few and weak measures to influence an innovative development process. The community can also actively promote alternative technology components that are less harmful to the environment, and according to Gøril Tjetland (2011) there is a lot of developed technology that could ease the impact the petroleum industry has on the environment. The technology is qualified and ready to use but no one is interested in adopting and implementing these innovations because economically there is no obvious reason to do so. The reason for this is that petroleum companies already have good working technology, and do not see any reason to change it with something that is only equally good in performance. The community influence alone rarely lead to decision being altered by petroleum companies or other stakeholders, but they often put focus on issues that often becomes attention of the media and politicians.

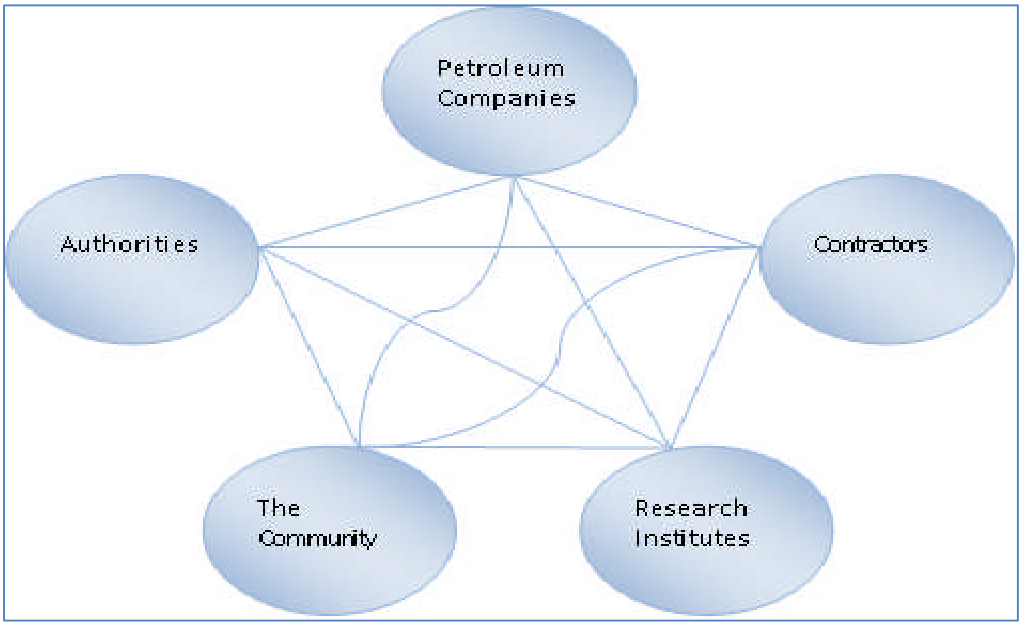


Figure 22 Stakeholder Relations at NCS

In figure 22 I have illustrate that the empirical data shows that the different stakeholders are aware of each other, that they have established contact with each other, and are oriented towards communication and cooperation. The lines running from the community to the petroleum companies and contractors are twisted to illustrate that it is difficult for the community to get their voice heard and be taken into consideration by the industry. However recent big petroleum related accidents have started to turn the focus from cutting costs and time, to more attention on HSE and increasing climate considerations. According to Inge Carlsen (2011) this is a permanent change in the industry where petroleum companies now have changed scorecards and how they assess value. With this change the community as a stakeholder are becoming more easily heard than before but they have not acquired more influence over innovative projects. In Norway the debate of petroleum activity at Lofoten/Vesterålen shelf have shown proof of this as the community managed to have their opinion taken into account, but only temporarily. They may not be equally successful in the future, as the Deep Horizon accident happened during this period and the public panic after the accident was high. But Petroleum companies learned from the accident that such huge accidents bring with them negative consequences in form of high clean-up costs, other aftermath costs, reduced reputation, halt in production, etc. I believe that it is not so much the pressure from the community stakeholder that have changed the petroleum companies way of assessing value, rather it is petroleum companies that are turning away from risks. As the world in general is becoming more concerned with climate change it has become more important to petroleum companies to demonstrate corporate responsibility to have a good reputation in the public eye, and because they are measured by it as it has become a competitive edge when it comes to winning licenses and tenders. Another 'new' environmental risk is connected to the fact that the most easily accessible petroleum is already found and thus new fields are often located in more challenging areas, with deep water (Deep Horizon), higher pressure, higher temperature, near foreshore, drift ice, super cooled water, etc. Common for both the 'new' environmental risks is that petroleum companies have to use more time planning and surveying before they can start operations or make big decisions; to make sure all possible precautions against potential accidents have been made. These 'climate adoptions' can potentially decrease petroleum companies' profit and thus less will be used on technology development, further it will have negative consequences on the technology development timeline because it will take more time planning and surveying before a development process can start.

5.3 The Institutionalized Technology Development Process at the NCS

Analysis of the empirical data shows that technology developments at the NCS follows the same phases as the innovative theory displayed in chapter two, but with an additional phase. The additional phase is the qualification/demonstration of technology that is an important and inevitable phase in the petroleum industry in Norway, and a phase that is critical to if the product of the development process becomes adopted/diffused and institutionalized. Qualification of technology is taking place after the development phase and before the commercialization phase. Some would argue that qualification could be included in the development stage, but the qualification efforts are so extensive and vital that it is rewarded with its own stage. The figure below illustrates how the institutionalized process of technology development is carried out at the NCS.

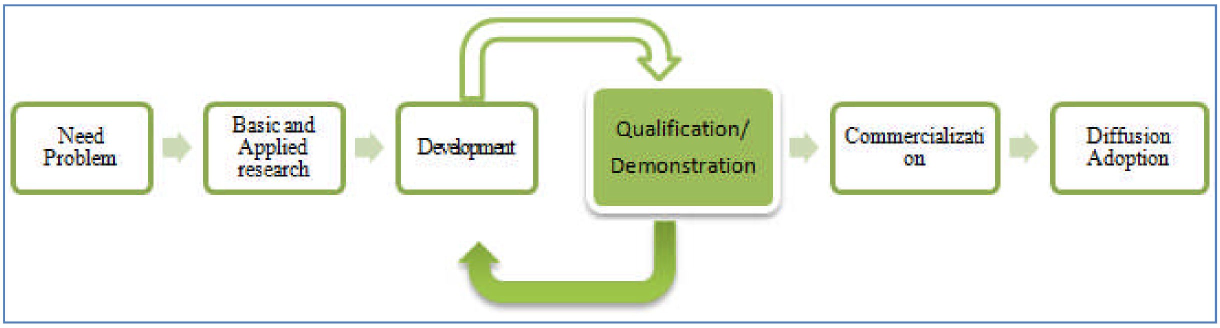


Figure 23 the Institutionalized Process of Technology Development at the NCS

The figure also illustrates that after development of a technological product, qualification testing will most often bring forward needs for adjustments or improvements. As a result further development of the product is necessary before it is able to pass through the qualification stage, thus the arrows back and forth between these two phases. The technology development process that is utilized at the NCS is very similar to that of the innovative theory; the reason is that the innovative process is a paradigm that has accumulated supporters and data that confirms the model over the years. As a result over time it has become a standard procedure for developing a product as people has found this to be most effective, and that if you omit one of the stages it may affect the end-result. Thus it has become the standard solution for developing a product, and therefore it is an institutionalized process. The normal progression that technology development at the NCS follows is hence very much an institutionalized process. This is why the innovative theory was chosen in the first place, because I assumed that it was applicable to Norway, and thus it was used as my starting point when I wanted to explore technology development. Technology development as an institutional process at the NCS can be shortened into the following three stages that I have named:

- Product Development
- Product Qualification
- Product Institutionalization

5.3.1 Product Development

At the NCS petroleum companies play the lead role when it comes to starting technology development since their challenges are dictating which efforts that are prioritized by all stakeholders, except the authorities. The challenges in Norway are triggering technology demands because it is jamming petroleum companies' operations in some fashion. In turn this will start an innovative project that aims to solve the problem. At the NCS such technology driven challenges can be divided into five groups:

- Acquiring licenses/tenders (showing capabilities)
- Harsh conditions (high costs, geology, pressure, temperature, depth, etc)
- Tail production (low pressure in reservoir requires etc. IOR/EOR)
- New discoveries (exploration technology, programs and knowledge to interpret data)
- Authority demands (health, safety, environmental, and other provisions or influences)

Common for these challenges are that they are related to finding petroleum and extracting petroleum under difficult conditions; as cost and production effective as possible. The difficult conditions offshore Norway are very costly to operate under compared to other petroleum producing countries, consequently technology is important for petroleum companies to better the profit margins and become more competitive compared to the rest of the petroleum producing world. Much of the future petroleum resources are located in much harsher environments than present reserves therefore the future will be even more dependent on technology than the past.

The empirical data suggests that the research & development environment at the NCS is very good, as new and groundbreaking solutions constantly are coming from contractors here making previously inaccessible petroleum resources available. Norway has since the 70's built up a very well functioning research & development infrastructure with many highly proficient institutes on petroleum issues. Except Norwegian companies, foreign corporations are very much present and helps drive the process forward with both knowledge and huge investments. Petroleum companies have some research they prefer to do themselves while other research is preferred assigned to contractors, research institutes, and universities. Derived from the empirical data the petroleum companies are doing research & development in their own facilities in regards to especially qualification efforts, but also in relation to the secrecy of creation and interpretation of seismic data.

Though the initiative to solutions or developments to the obstructive problem can come from any of the stakeholders at the NCS, it is however a limitation that most stakeholders have small margins and the authorities and/or a big petroleum company's presence is usually required to be able to start a development project. This is especially true for research institutes and universities and can be considered a weakness but unfortunately it seems that both the authorities and petroleum companies feel that they enough basic funds to solve their missions. Additional funds can easily be provided later if they see need for it. Research institutes and universities will always be dependent on external funding, while contractors are more independent, but still dependent on autorities or a petroleum company sooner or later in the process. The latest trend is that more contractors are saving money for research & development efforst and clearly wants to rid themselves of some of this dependency of others. Big petroleum companies with lots of funding can allow themselves to use research & development as a playground where they can experiment. Smaller petroleum companies cannot do this as they have to be on the lookout for fast cash-flows so that they in turn can grow and later be able to contribute with research & development. The Authorities are facilitating and making it easier for small and medium sized companies to participate, but when it comes to development it seems that the large contractors are winning most tenders, and one can only assume that it is because they are better qualified to solve the assignment.

The authorities expect that the industry comes up with solutions to challenges, but sometimes the industry do not initiate because the economic and technical risk is too high. This is why the authorities are always looking at issues that are socioeconomic valuable in the long run, and that is not initiated by the industry on its own. Many of these issues are covered by the authority's programs and through their applied pressure, which reflect the long term petroleum technology strategy OG21. Thus in the Norwegian petroleum industry there exists a mission allocation when it comes to research, development, and innovativeness that ensures that all important aspects and issues are considered and dealt with. The division of responsibility has come natural since petroleum companies (and the industry in general) are mostly concerned with short-term challenges in specific fields, and vigilant Norwegian authorities are picking up the loose ends and takes responsibility for long-term issues. This is according to their long-term strategy and assures good interaction between the authorities, research institutes, universities, and the petroleum industry. They leave nothing to up to chance, rather deal with all possibilities as soon as possible.

In relation to the first bull-point above (acquiring licenses) some respondents mentioned that competition can sometimes ruin an open technology arena in relation to the exploration phase. In the exploration stage petroleum companies and contractors compete with their colleagues within each their stakeholder group for respectively licences and tenders. This completion gives the stakeholders incentives to be better than their competitors in terms of capabilities and technologies. At the NCS this has lead to an 'arms race' of knowledge and innovations since it enhances capabilities and the probability of winning contracts on the most promising licenses. The technology related to exploration of petroleum is known, but the competition is related to knowledge, i.e. programming, interpretation of data, analyzing results, etc, and thus initially a competition for the best human resources. In the phases of production and field development there is little competition and they can only do their best while monitoring their competitors closely and perhaps benchmark competitors if they have better solutions. The conclusion is therefore that in both instances the rivalry is mainly between actors within the same stakeholder groups and can only be viewed upon as healthy competition. However if secrecy becomes too big it could reduce and weaken small and medium sized stakeholders' ability to participate as they would potentially be shielded-off technology important and necessary to operate at the NCS.

5.3.2 Product Qualification

After a prototype is developed intensive and realistic testing is carried out, sometimes together with other components, in accordance with petroleum companies' specifications. Only when the petroleum company is a hundred percent sure that the innovation will function well under the right conditions will they approve the innovation and end the qualification stage. Not all developments manage to become commercially successful and qualified technology will be much easier to commercialize and sell compared to un-tested technologies, since they hold promise of high quality. The buyer feel reassured knowing this which in turn makes their decision-making efforts less, and qualification of technology is therefore very important for the diffusion of the developed product. Qualification of technology happens for the most part at facilities in operation and thus all developers are dependent on petroleum companies' willingness to let qualification processes take place at their installations. Only petroleum companies and the authorities have the economic muscles and operative production facilities needed to conduct qualification testing. From the perspective of the operator and the fields owners qualification can be a double-edged sword since on the positive side it could lead to acquiring of technologies that could improve their operations, but from the negative perspective lose income due to halt in operations. Not to mention increased risks of accidents when they have to shut down well run operations and open up an 'experiment' instead. Qualification is done in cooperation between the petroleum companies and contractors. The authorities often hear from the industry that it is challenging to qualify technology at the NCS at the moment, and that many feels that Statoil with its dominant role could have done more (Reidar Müller, 2011). In bad times like just now in Norway with just few and small discoveries (with one exception), big petroleum companies are putting off qualification projects because small reserves cannot support technology development. The authority's financial contribution to qualification to technology development is also considered to be very small compared to other initiatives. Statements in the empirical chapter indicate that there is a bottle neck in the qualification stage and that more technologies could have been qualified and made available to the market sooner. This would contribute to increase the production at the NCS faster had only the additional funding and willingness for qualification efforts been supplied from both petroleum companies and the authority. From the authorities perspective they only want to stimulate private initiative and are doing that by funding qualification efforts with just under 50 million NOK each year, which triggers private investment 3-4 times that of the authority's funding. But DEMO2000 was initially supposed to be funded with around 100 million NOK each year. In addition the OG21 strategy report, the extraction committee, and experts recommends that authority funding for demonstration of prototypes and conduction of pilot testing to be increased significantly to at least 100-150 million. With all these facts produced from within the authorities itself it is a paradox that not more funding has found its way to qualification/demonstration efforts long time ago as it seems clear that the need is there and everybody knows it.

5.4 Product Institutionalization

5.4.1 Habitualization

In the pre-institutional stage the product has been developed and is finished testing and has successfully been qualified. Habitualization is about making the product known and available. Both the process of institutionalization and the innovative theory's S-curve indicate that only a few early adopters acquire the innovation at this stage. At the NCS it is like the theory describes; at this stage adoption is mostly an independent action and adoption rates are low, often just a single petroleum company that is part owner of the developed product. The reasons for low adoption rates is that most qualified innovations are made with a specific usage or location in mind and thus not necessarily fitting other fields without adjustments that could require a new qualification round. Further many end-users cannot afford to buy new technologies or they just do not see the value in changing working components with something new. The theory also mention that adoption at this stage could be slowed down because of lack of consensus of utility of the product and internal risk aversion. Related to the NCS it can be smart to wait to adopt since there is a huge difference between testing and actual usage over several year. Adoption is also low because at the NCS some potential buyers chose to wait and gather more information so that they better can assess the utility and the risk of adopting the product. In addition one can also get information on how easy/hard the innovation is to maintenance. This is information that quickly can make a very promising technology look unattractive. If there are more than one adopter to this technology after the initial release it is most likely that they have cooperated in developing the product since they are facing the same problem. Thus even though the product is qualified there are still reservations that will contribute to low adoption rates at this stage because potential customers perceive high uncertainty related to change to something different, technologically and economically adoption can be impossible for some, and the existence of already implemented working technology. The product, how perfect it might be, will still not be the first solution potential customers think of when they contemplate on their challenge.

5.4.2 Commercialization and Objectification

In the semi-institutionalized stage of objectification the product has become fairly widely diffused and institutionalization at this level dependents on end-users common and favourable perceptions of product. At the NCS the developer (champion) will contribute to similar perceptions of an innovation through commercializing (theorizing), by highlighting the innovations benefits and results from testing and by connecting it to a specific challenge. Except from the champions theorizing, information on a product are also reaching potential customer through the first reports from early adopters, media, colleagues, networks, and other information channels. According to the institutional theory potential customers will consciously monitor the accumulation of evidence on the quality and effectiveness to use in own assessments. In innovative theory the S-curve confirms this by illustrating how adoption rates are connected with the performance of the product. Petroleum companies are known for being quite conservative in their decision-making because of high investment and risk involved and some will still want to gather own information to make sure that the product have required quality and usage. This is the case in Norway too regardless of a product has been qualified. The consequences of buying the wrong product are so big that customers want to do own evaluations. At the NCS there is little discussion concerning products functionality after such extreme testing, rather the questions potential customers are asking themselves are; is the product going to work the way we are going to use it? How long will the product last? How many times does it need maintenance during that time? Benchmarking of competitors is a strategy used by potential customers as a way of reducing uncertainty and keeping costs low by imitating and copying successful solutions. North Energy acknowledge that they are using this strategy because it saves time, costs, and keeps risks lower than if they were to develop something of their own, while Statoil stimulates innovativeness in others and then adopt qualified solutions rather than undertake huge developments on their own. Both cases are efforts made to avoid and share the risk with others. In Norway when a solution has proven that it works offshore news of its excellence will travel fast and potential customers with similar challenges will show their interest. In contrast to the previous phase uncertainty to change to the product is much less and contributes to higher adoption rates because reports from early adopters and subsequent benchmarking of others that have already implemented the product with success. The high quality standards that are used in Norway and the fact that developers there are concerned with protecting their patented rights and continuously improving their products are all contributing to increasing adoption rates. In addition the Norwegian authorities have also made a target in their OG21 strategy to increase export of technology, and developers at the NCS are indeed exporting technology and wanting to export more. While technological and economical viability is also applicable in this stage and together with thoroughly decision-making process it keeps the adoption numbers from sky-rocketing. Thus more customers are adopting the product at this point due to; high quality, commercialization efforts, and benchmarking, which all contributes to increasing the adoption rate and the level of institutionalization.

5.4.3 Fully Diffused and Institutionalized

In the last stage of sedimentation, fully institutionalization depends on continuity of the established structure amongst end-users. This means that the product have to be adopted by the majority of potential customers and that they utilize the product over a longer period of time. Both the innovative theory and institutional theory points to the necessity of continuous usage over a longer period in time. Opposed to the two previous stages; petroleum companies' conservative decision-making will at this stage help maintain cultural support and promotion of the product that is now fully institutionalized. At the NCS operators are very careful to make changes because of the high cost/risks involved and therefore they tend to hold on to what works rather than implementing new solutions, unless the new innovation can save costs or increase efficiency. At the NCS qualified, commercialized, and widely diffused technology holds promise of such high quality that stakeholders will at this point have no reservations weather to adopt or not. Some late adopters are at this stage joining in as the adoption rate is about to flatten out and the only thing that could stop someone from implementing the solution is what is technical and economical viable for the organization. The theory mention that it is important for continuity to have interest group advocacy to resist 'negative' interest groups, and the petroleum industry is especially exposed to 'negative' interest groups that in some extreme cases can influence petroleum companies operations. Developers at the NCS have their seller teams and information consultants that maintain the products reputation, and it's important that these people are aware of the public opinion in relation to their business. At the NCS there have been some opposition but the petroleum industry have stepped forward with cautiousness and shown etiquette. Most technological developments that are coming out of the NCS are applauded and are virtually selling themselves. The institutional theory also mentions that lack of demonstrable results could hinder institutionalization, and this is further backed by the S-curve in innovative theory. In the context of technology development at the NCS it would equal a situation where the innovation is not delivering results as those accomplished during the qualification. This study have not found indications that it is something that occurs in Norway today and if such a situation would occur it is likely that it would happen at an earlier stage, and at the latest during the qualification process. In the offshore petroleum industry such an outcome is catastrophic with huge sunk costs and this is why testing and re-testing during the qualification phase is very important to petroleum companies operating at the NCS.

5.5 Summary Analysis

In this chapter I have highlighted important aspects within utilized theories and analysed the empirical data and drawn parallels to the petroleum industry in Norway. First we have seen how institutional isomorphism is present at the NCS and making stakeholders more similar to each other and together with stakeholder relations it is viewed as part of the petroleum industry framework. The institutionalized technology development process with its different stages has been explored and important aspects have been highlighted and factors that can slow down the process indicated. In the end important aspects from the institutional process have been discussed in relations to the petroleum industry in Norway.

6. Conclusion

This thesis has explored the institutionalized process of technology development at the NCS by looking at the; external framework that surrounds the process, stakeholders of the process, the stages in the process. The goal has been to identify factors that contribute to slow down the technology development process. In this chapter I will therefore try to sum up and conclude on the situation around the technology development process at the NCS.

6.1 The Institutional framework/Stakeholder Relations

As a host-government controlling valuable natural resources Norway has rigorous regulations and high taxes, but has also implemented incentives for research and development in the framework. Strict regulations are nicely balanced with functional demands in relations to how to operate, and the BAT arrangement in relation to which technology to use in operations. Petroleum companies are virtually free to use the solution they want in operations, but at the same time they alone carry the responsibility for potential accidents. In Norway this solution is working well but there have been some issues related to safety, but not outdated technology. Norway seems to have found a balance that is close to an ideal research & development environment, and with strategies and long-term perspective. OG21 strategy and other governmental documents related to petroleum research are ensuring a coordinated effort between universities, research institutes and the petroleum industry. These stakeholder use each other’s expertise and cooperate when necessary, behaviour which has resulted in a large and open innovative environment. The only thing in the framework that potentially is slowing down the technology development at the NCS is the funding (highlighted soon) and the ‘new’ environmental risks that forces developers to make economical unfavourable preliminary studies, beyond those that is already required.

6.2 The Institutional technology process

The challenges related to extracting petroleum are creating demand for technology development efforts and therefore it is challenges belonging to petroleum companies. The efforts to solve the challenge are done in cooperation between petroleum companies and stakeholder resources that are present at the NCS and on the main land. Except from the petroleum companies, the authority, and some few large contractors most stakeholders have limited funds and few means to start something on their own. If a stakeholder is lucky they might get stimulation from the industry or through authority programs in an area where they have expertise. Otherwise the empirical data indicate that financially weak stakeholder find the funding of independent research & development to be insufficient, while the financially strong stakeholders seems to think the amounts to independent research are suitable. It can be bad for generation of new ideas that potential developers are not allowed to do more independent research & development and it can be an idea to increase the funding. Never the less all stakeholders have possibilities to be part of petroleum technology development.

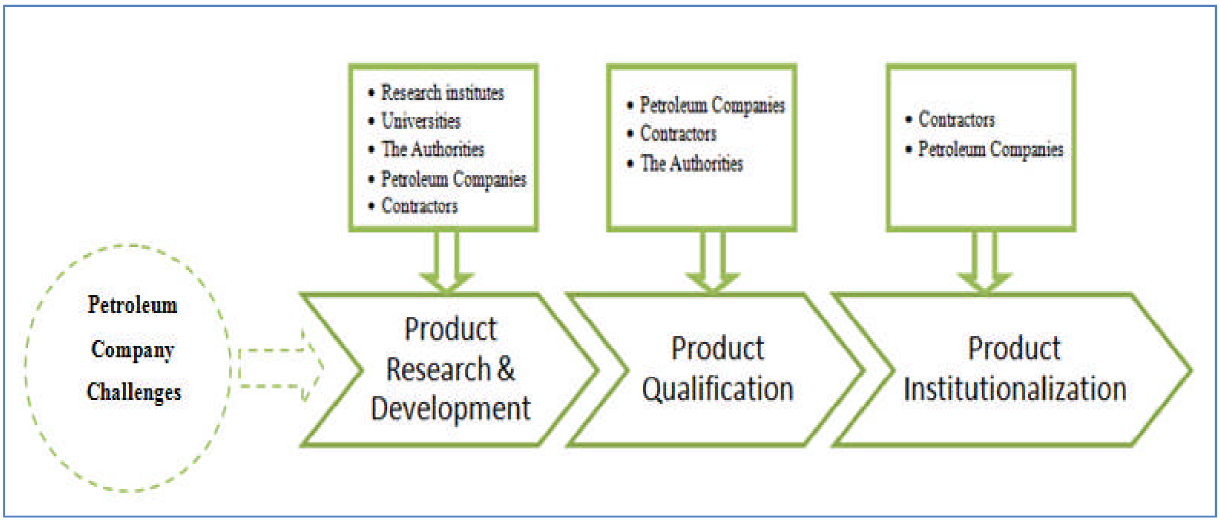


Figure 24 the Institutional Technology Development Process at the NCS

The figure illustrates the technology development process at the NCS with the extraction challenges leading up to the process. Above each stage a boxes with stakeholder names is placed, illustrating participants in each stage. Together with contractors' the petroleum companies are doing most of the applied research, while research institutes, universities, and to some extent contractors, are doing the basic research. It seems appropriate that petroleum companies and contractors are doing most of the applied research concerning details since they are part of developing the product together, while the research institutes and universities, with the authorities in front, are responsible for the more important and time-consuming effort to overview environment and the bigger details. After research is done the rest of the stages are mainly done by the petroleum company and the contractor. In the qualification stage it is the contractors that develops the product but according to petroleum companies' specifications in terms of quality and functionality. This is a two-way interaction with the contractors at the wheel in this phase as they 'steer' the progression, and the petroleum companies monitoring every step to make sure that it is done according to specifications.

The product qualification is the bottleneck in the technology development process at the NCS, and only the petroleum companies and authority have the financial ability to do something about the situation. After 10-15 years with few and small discoveries petroleum companies have lost their willingness to participate in piloting projects because small findings cannot support development. This has put the responsibility on contractors that which has made them prioritize petroleum matters less. In such down periods perhaps the authorities could have increase and spur more efforts, and maybe Statoil could have shown more long-term thinking and willingness to keep the process run more smoothly all the time independently of 'seasonal variations'. Authority appointed committees and other sources confirms that need for more funding for qualification of technology is there, so it is a paradox that there haven't been bigger increases in qualification efforts already. The only explanation can be that there is a lack of willingness from both petroleum companies and the authority since everybody seems to acknowledge the need.

Related to the NCS, characteristics of the product institutionalization process are after the release of the product that the adoption rates are low, and if more than one petroleum company adopts the product it is more than likely that they have cooperated in the developing. There seems to be three reasons to why there is low adoption rates at this point; first existing already implemented technology, second because of uncertainty and technical & economical viability, third it can be smart to wait for several reasons and gather more information before implementing. In the mid-product institutionalization when the product has been utilized by early adopters for some time, the diffusion accelerates both because of information from the developer but also from own surveys. Information on new available solutions travels fast at the NCS and no one is holding back technology, but still what is technical and economical viable is slowing down implementation. In this last stage of product institutionalization petroleum companies' conservative decision-making contributes to maintain continued usage of a product that is already commercially successful and fully institutionalized. Petroleum companies do not change something that works unless it can save costs or increase efficiency.

As a conclusion of it all I would say that this study has revealed mostly positive things related to the technology development at the NCS. It is a great environment for innovativeness but there are issues slowing down the process but not more than that successful technology is produced from there. Just maybe not as much development as one could hope for since production and reserves have declined and harsher and more unavailable conditions are waiting in the future. In Norway it takes a long time between when ideas come to mind and the product is created, and long time between investments are made in new technology developments or qualification projects. Successful technology development has materialized in skilful clusters but still the technology development is not running at full speed. Technology development is an area of possibility and growth for a country like Norway, and Norway has a comparative advantage in offshore petroleum operations. Thus the conclusion is that most things are going well, but the qualification and implementation of technology is slowing down the development process, and more funding could and should be injected into petroleum research and development efforts.

7. List of References:

7.1 Books

Bell, E., and Bryman, A. 2007. Business Research Methods. Oxford University Press.

Berg, B. L. 2009. Qualitative Research Methods – For the Social Sciences. Allyn & Bacon, London.

Denzin, N. K., and Lincoln, Y. S. 1998. The Landscape of Qualitative Research – Theories and Issues. SAGE Publications, Inc. Thousand Oaks, California.

Easterby-Smith, M., Jackson, P. R., and Thorpe, R. 2008. Management Research. SAGE Publications Ltd. London.

Freeman, E.R., Harrison, J.S., and Wicks, A.C. 2007. Managing for Stakeholders: Survival, Reputation, and Success. Yale University Press. New Haven & London.

Hurst, D., and Viber, C. 2004. Theories of macro-organizational behaviour: a handbook of ideas and explanations. M.E. Sharp, Inc.

Sellerberg, A-M. 1994. A Blend of Contradictions: Georg Simmel in Theory and Practice. Transaction Publishers. New Brunswick. N.J., U.S.A.

Ringdal, K. 2007. Enhet og Mangfold; Samfunnsvitenskapelig forskning og kvantitativ metode. Fagbokforlaget Vigmostad og Bjørke AS.

Rogers, Everett M. 2003. Diffusion of Innovations. The Free Press. New York.

Rogers, Everett M. 1995. Diffusion of Innovations. The Free Press. New York.

Ruan, J.M. 2005. Essentials of Research Methods: A guide to Social Science Research. Blackwell Publishing, Oxford, U.K.

7.2 Articles

DiMaggio. P. 1988. "Interest and Agency in Institutional Theory." In Lynne G. Zucker (ed.), Institutional Patterns and Organizations: Culture and Environment: 3-22. Cambridge, MA: Ballinger.

DiMaggio, P., & Powell, W. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields". American Sociological Review vol. 20: 147-160.

Donaldson, T., & L. Preston. 1995. "The Stakeholder Theory of the Corporation: Concepts, Evidence and Implications." Academy of Management Review vol. 20, no. 1: 65-91.

Freeman, Edward, R. & Reed, David, L. 1983. "Stockholders and Stakeholders: A New Perspective on Corporate Governance". California Management Review vol. 25, no. 3: 88-106.

Gueterbock, R. (2004) Greenpeace Campaign Case Study-Stop Esso. Journal of Consumer Behaviour, 3:3 265-271.

Isaksen, Arne. 1999. Regionale innovasjonssystemer – Innovasjon og læring i 10 regionale næringsmiljøer. R-02 av STEP-gruppen for Norges forskningsråd, Oslo.

Tolbert, S.P., and Zucker, G.L. 1996. The Institutionalization of Institutional Theory. In: Clegg, S., Hardy, C., and Walter, R.N. 1996. Handbook of Organization Studies. London and Thousand Oaks: Sage Publications: 175-190.

7.3 Reports and Documents

The Norwegian Ministry of Finance, St.meld. nr. 2 (1998/1999): The revised national budget 1999

Oil and Gas in the 21st century strategy document, 2001. Norway's Technology Strategy for the 21st century

Norwegian Academy of Technological Sciences and Offshore Media Group, 2005: Petroleum Research Pays Off

Tor Borgar Hansen, Tore Karlsson and Helge Godø, NIFU STEP, rapport nr. 7, 2005. Evaluation of the DEMO 2000 program

The Norwegian Ministry of the Environment, St.meld. nr. 8 (2005/2006): Integrated management of the marine environment in the Barents Sea and the waters off Lofoten (management plan)

David Johnston, Daniel Johnston and Tony Rogers, 2008. International Petroleum Taxation – for the independent petroleum association of America. IPAA, America's Oil & Gas Producers

Harald Tønnesen in the Norwegian Petroleum Museum yearbook, 2008. Development at the Norwegian Continental Shelf – Political constraints and technological choices

The Norwegian Petroleum Directorate commissioned by The Norwegian Ministry of Petroleum and Energy: Petroleum resources in the waters outside Lofoten, Vesterålen and Senja, 2010

North Energy annual report 2010

The Norwegian Ministry of Petroleum and Energy with the Norwegian Petroleum Directorate: Facts 2010 – Norwegian petroleum operations

The Norwegian Ministry of Petroleum and Energy, report from the Extraction Committee, 2010: Increased production on the Norwegian continental shelf

The Ministry of Petroleum and Energy and the Ministry of Labour, 2010: Guidelines for plans for development and operations of a petroleum deposit and plans for installation and operation of a petroleum deposit (PDOs) and plans for installation and operation of facilities for transport and utilisation of petroleum (PIOs)

The Norwegian Ministry of the Environment, Meld. St. nr. 10 (2010/2011): Update of the management plan for the marine environment in the Barents Sea and the waters off Lofoten

The Norwegian Ministry of Petroleum and Energy, Meld. St. nr. 28 (2010/2011): An industry for the future – Norway's petroleum activities

The Norwegian Oil Industry Association: Economic report 2011 – Optimism in the Norwegian petroleum industry-but a darker outlook for the world economy

Petoro Annual Report, 2011 – Petoro's Management and Control

The Norwegian Ministry of Petroleum and Energy with the Norwegian Petroleum Directorate: Facts 2012 –Norwegian petroleum operations

7.4 Internet (Lecture notes)

Cato Willie, 2011. As cited by Jan Terje Henriksen in Norwegian Perspectives' Lecture: Technology Development on the Norwegian Continental Shelf.

Central Bureau of Statistics. Petroleum Production First Half 2011. Downloaded February 4, 2011: http://www.ssb.no/ogprodre/

Open Innovation perspectives - the development of the Norwegian Continental Shelf. Steinkjer. 18.9.2009. Cato Willie, Chief Researcher, Ideas and Innovation Management, StatoilHydro ASA. Downloaded August 16, 2011: http://www.innovasjon.eventweb.no

8. Appendix

Appendix 1: Interview guide (Tentative)

Innovasjonsprosessen

1. Hvordan håndteres innovasjonsprosessen og hvilke faser består den av?
2. Hva utløser prosessen?
3. Hvordan stimuleres oppgavene; kommersialisering og spredning av teknologi?
4. Vanlige problemer/løsninger knyttet til prosessen?

Teknologiutviklingens aktører

1. Hvordan fungerer samarbeidet? (Stat, utdanningsinstitusjoner, forskning, industri)
2. Er det aktører som ikke deltar optimalt?
3. Hvordan får dere kjennskap til nye teknologiske innovasjoner?
    - Hvordan spres slike nyheter mellom aktørene i industrien?
    - Er det vilje til å dele på ny teknologi vs. konkurransefortrinn?
4. Hvilket eksternt press, og fra hvilke aktører, kan påvirke hvordan valg dere gjør?

Teknologivalg (Institutionalization)

1. Hvilke begrensninger eksisterer i forhold til hvilken teknologi man kan ta i bruk på norsk sokkel i forbindelse med leting/produksjon av olje og gass?
    - Søknadsprosess, faser, godkjenning eller lignende?
2. Hva er avgjørende for hvilke teknologiske løsninger som implementeres på norsk sokkel?
    - Hva er avgjørende faktorer for at en teknologisk løsning forkastes/utgår
    - Er det aktører som er avgjørende for hvilken teknologi som implementeres?
    - Hvorfor velges en løsning, mens alternativet blir forkastet?
3. Hvilke teknologiske innovasjoner har de siste årene 'slått gjennom' og blitt tatt i bruk av majoriteten på norsk sokkel? (kategorier)

Stakeholders

1. Hvordan har utviklingen endret måten vi må ta hensyn til stakeholders på?
2. Hvilke betydning har dette "ekstra" hensynet fått å si for teknologiutviklingen?
3. North Energy undersøker muligheten for et tunnelkonsept i forhold til utvinning av olje og gass i kystnære områder,
    - Hva er deres syn på en slik løsning?
    - Kan tunell konseptet være med på å løse utfordringer tatt opp i debatten om oljeutvinning i Lofoten/Vesterålen området?

Appendix 2: Authority Funding of Petroleum Research & Development

Fra: **Espen Forsberg Holmstrøm** <efh@forskningsradet.no>
Dato: 11:56 25. august 2011
Emne: VS: Tall for bevilgninger til petroleumsforskning
Til: stenna@gmail.com
Kopi: Siri Helle Friedemann <shf@forskningsradet.no>

Hei Sten-Are,

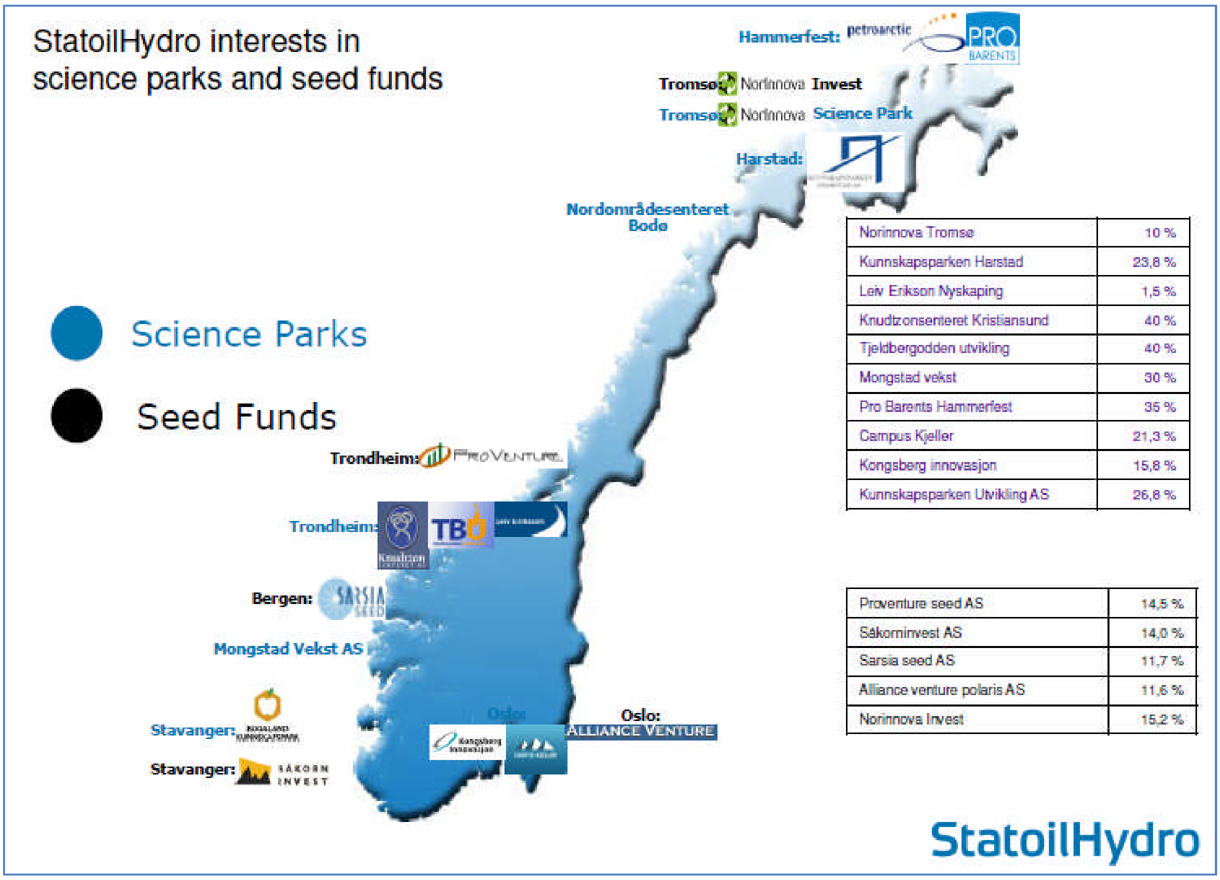
Under følger Forskningsrådets budsjettutvikling innen petroleumsforskning. Det er viktig å understreke at tallene er historisk budsjettutvikling, altså pengestrømmen inn til de forskjellige programmene fra departement/fond. Om man sammenlikner dette med tall som viser pengestrømmen ut fra Forskningsrådet, så vil det være forskjeller.

Budsjettutvikling 2002-2011	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SFF CIPR UiB (Forskningsfondet)	0,0	14,0	14,0	14,0	14,0	14,0	14,0	14	14	14
Strategisk petroleumsforkning (OED, NHD, KD)	65,9	62,6	60,1	58,9	63,1	84,4	82,6	77,9	77,9	92,9
Petromaks (OED, NHD, forskningsfondet)	0,0	0,0	55,0	162,3	236,1	228,2	223,0	181	212	207,5
Petromaks: HMS (AD)	15,0	15,0	15,0	15,0	15,5	15,4	18,9	18,8	18,8	18,8
Brukerstyrt/anvendt ekskl Petromaks (OED, NHD)	41,1	41,1	39,4	0,0	0,0	0,0				
Effekter av utslipp til sjø (OED, MD)	2,0	8,0	8,0	8,0	8,0	8,0	8,0	10,5	10,5	10,5
Demo2000 (OED)	20,0	29,0	30,0	50,0	70,0	50,0	50,0	42	48	46,7
Samfunnsfaglig petroleumsforskning (OED)	6,4	5,2	5,2	5,2	5,2	10,0	10,0	10	10	10
Demo 2000 tiltakspakke 2010									50	
Total petroleum RD&D	150,4	174,9	226,7	313,4	411,9	410	406,5	354,2	441,2	400,4

Håper det blir mulighet til å lese den delen som omhandler vår virksomhet. Lykke til med oppgaven.

Vennlig hilsen
Espen Forsberg Holmstrøm

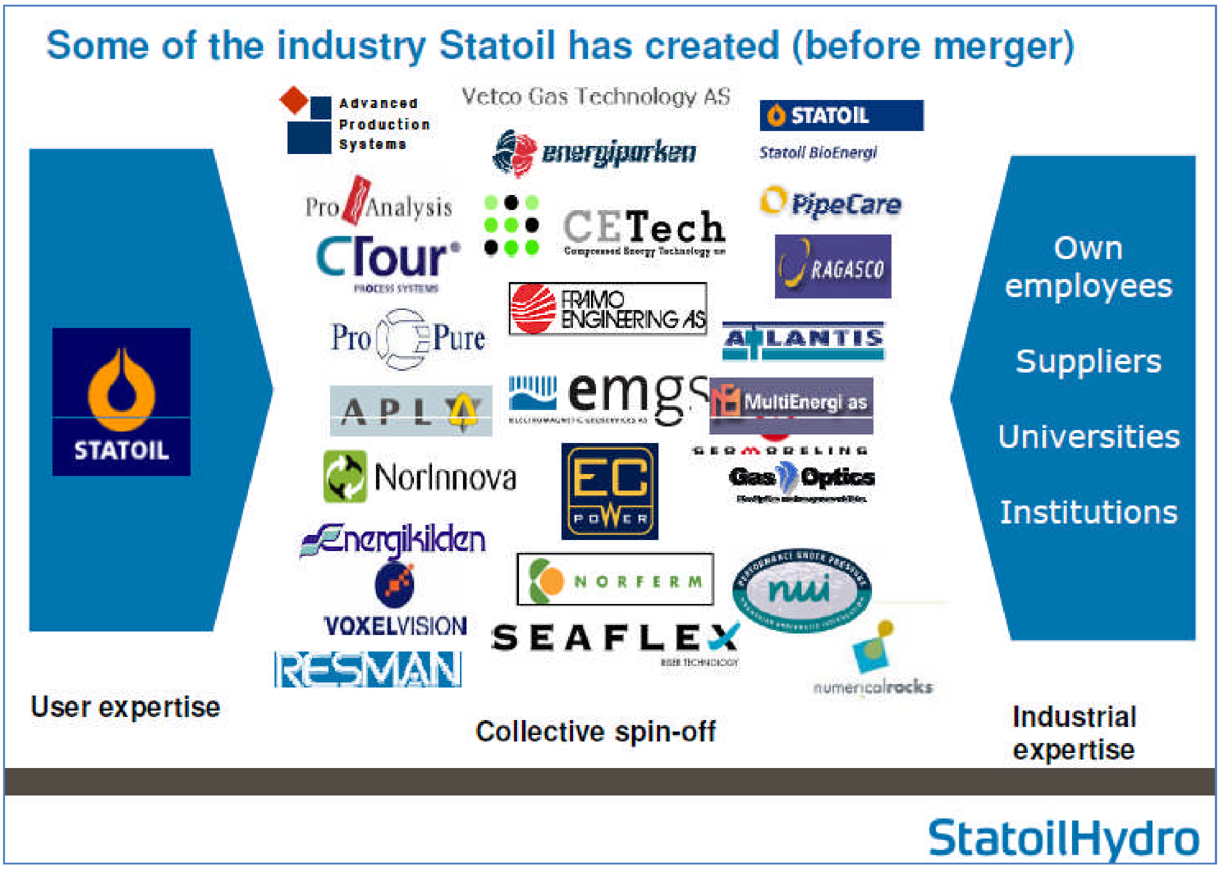
Appendix 3: Statoil's interests in science parks and seed funds



Norinnova Tromsø	10 %
Kunnskapsparken Harstad	23,8 %
Leiv Erikson Nyskaping	1,5 %
Knudtzonsenteret Kristiansund	40 %
Tjeldbergodden utvikling	40 %
Mongstad vekst	30 %
Pro Barents Hammerfest	35 %
Campus Kjeller	21,3 %
Kongsberg innovasjon	15,8 %
Kunnskapsparken Utvikling AS	26,8 %

Proventure seed AS	14,5 %
Såkorninvest AS	14,0 %
Sarsia seed AS	11,7 %
Alliance venture polaris AS	11,6 %
Norinnova Invest	15,2 %

Appendix 4: Statoil development spin-offs



Preface

This master thesis marks the end of my master program of Energy Management at the University of Nordland and is my final work of a period that has been highly educational and personally developing. In addition to many interesting lectures during the Energy Management program the choice of thesis topic was crucial to my goal to get more in-depth knowledge about a topic that is essential to the petroleum industry and its future. Writing this thesis has been a learning process on many levels, both in designing and develop this paper and by acquiring more in-depth knowledge of the petroleum industry through contact with major actors in the industry.

I wish to thank my supervisor Anatoli Bourmistrov (associate professor, PhD) at the University of Nordland for leading me towards this interesting topic regarding industry technology and for providing me with tips on theories that could be relevant. Further his constructive guidance has helped improve the end-result of this thesis.

In the end I would like to express appreciation to my respondents that have put aside time for an interview in an otherwise hectic and busy working day. My respondents have provided extremely valuable information and given me the opportunity to learn by exploring into a very interesting data set.

Sten-Are Johansen

Tromsø, may 23, 2012.

Abstract

This thesis is exploring technology development at the Norwegian Continental Shelf by looking at the different stages in the process, the stakeholder's role and involvement in the process, and characteristics of institutional solutions that are chosen. The institutionalized solutions or standards can through theory explain why things are the way they are. The institutional technology development process that starts when a need or a problem demands a technological solution via product development arises, and through diffusion of that development. The objective of this thesis is to explore the different aspects of the process and point to obstructions or factors that are slowing down the process. To illuminate this process possibly entries to technology development has been explored from different perspective, the stakeholder's cooperation and contribution to technology development are explored, and in the end the authority framework was studied. The main conclusion of this thesis is that Norway has a good balanced framework with a high level of cooperation that stimulates technology development, but there are issues that are slowing down the technology development at the NCS. Some of the factors that have come to surface are; limited possibilities to participate in developments, limited funds for independent research, bottleneck in technology qualification, and 'new' environmental risks. All the factors that slow down the development basically boil down to awareness of required levels of funding and willingness and ability to invest. This might come out quite negative but Norway is doing all the essential things right and many good technologies are produced there. But for as a country like Norway with lot of potential and money could use this advantage to make technology development an even more prioritized area.

Sammendrag

Denne masteroppgaven har valgt å undersøke teknologiutvikling på norsk sokkel ved å se på de ulike stegene i prosessen, ved å se på interessenters rolle og involvering i prosessen, og karakteristikker ved valgte institusjonaliserte løsninger. Institusjonaliserte løsninger eller standarder kan gjennom teorien forklare hvorfor ting er som de er. Den institusjonaliserte teknologiutviklingsprosessen starter ved at et behov eller et problem krever en teknologisk løsning, til man utvikler et teknologisk produkt og prøver å spre det for å gjøre det til en kommersiell suksess. Formålet med oppgaven har vært å undersøke de ulike fasene av teknologiutviklingsprosessen og peke på faktorer som hindrer eller bremser teknologi utviklingsprosessen. For å belyse denne prosessen ble muligheter for deltakelse in teknologiutvikling undersøkt fra forskjellige perspektiver, interessentene samarbeid og bidrag i utviklingsprosessen ble undersøkt, og til slutt ble også myndighetenes rammeverk undersøkt. Hovedkonklusjonen fra denne masteroppgaven er at Norge har et godt og balansert rammeverk med et høyt nivå av samarbeider som stimulerer til teknologiutvikling. Men det er noen faktorer som bremser teknologiutviklingen som er funnet i denne studien er; begrensede muligheter for ulike interessenter til å delta i utviklingsarbeid, lite tilgjengelig kapital til selvstendig forskning, kvalifisering av teknologi virker som en flaske hals på resten av prosessen. Alle faktorer som bremser ned utviklingen koker i bunn og grunn ut i kunnskap om nivået på nødvendig satsning og vilje og mulighet til å investere. Dette kan høres noe negativt ut, men faktumet er at Norge gjør alt det essensielle riktig og mang gode teknologier blir produsert der. Men for Norge som et land med stort potensial og økonomiske muskler kunne ha brukt denne fordelen til å gjøre teknologiutvikling et mer prioriter området.

List of figures

Abbreviations

BAT – Best Available Technology

DEMO2000 – Program for Testing and Qualification of New Technology

EOR – Enhanced Oil Recovery (immobile oil)

FNI – The Federation of Norwegian Industries

FORNY (2020) – Commercialization of Research and Development Results

FPSO – Floating, Production, Storage, and Off-loading (unit/vessel)

GASSMAKS – Program for Increased Value Creation in the Natural Gas Value Chain

HAVKYST – Ocean and Coast; Precautionary-based Management of Marine Ecosystems

HSE – Health, Safety and Environment

IOR – Increased Oil Recovery (mobile oil and/or immobile oil)

JIP – Joint Industrial Project

MPE - The Ministry of Petroleum and Energy

NCS - The Norwegian Continental Shelf

NPD – The Norwegian Petroleum Directorate

NOK – Norwegian Kroner

NUST - The Norwegian University of Science and Technology

OLF – The Norwegian Oil Industry Association

O.E – Oil equivalent

PETROMAKS – Program for Increased Value Creation for the Petroleum Resources

PETROSAM – Program for Social Science in petroleum research

PIO – Plan for Installation and Operation

PSA – The Petroleum Safety Authority Norway

PDO – Plan for Development and Operations

RCN - The Research Council of Norway

SCM – Standard Cubic Meter

SDEA – The States Direct Economic Assets

CER – Centres of Excellent Research

CRI – Centres for Research-based innovation

Content Index

1. Introduction and Problem Statement

1.1 Actualization and Background

At the Norwegian Continental Shelf (NCS) the oil production is decreasing rapidly as the oil fields are maturing while new discoveries are few and far between. Now in the beginning of the 21st. Century most of the promising areas in Norwegian territory are presumed to have been mapped and the biggest and most easily accessible petroleum resources are already located, while new discoveries are mostly small and far between and much harder to reach and extract than in the past.

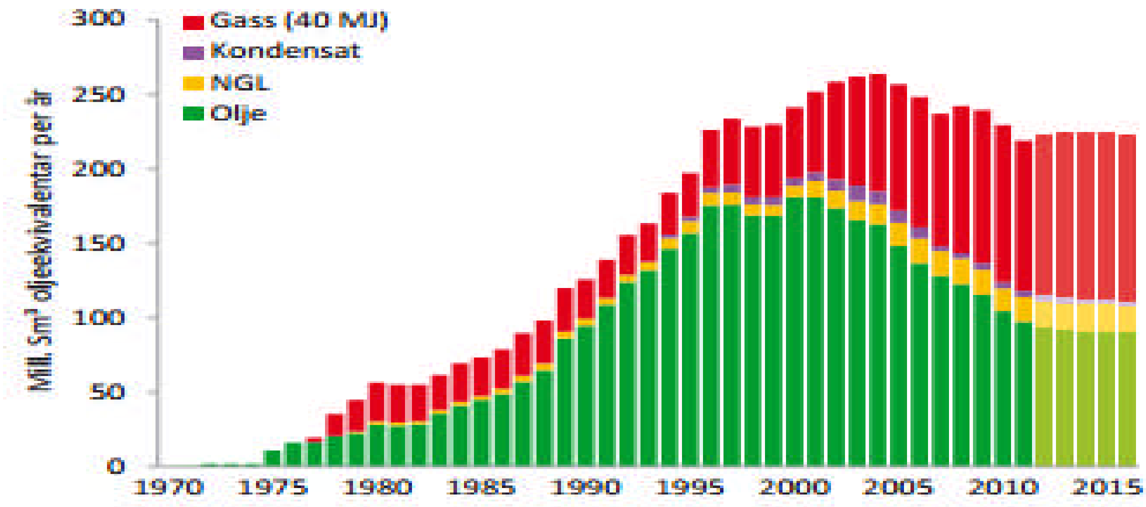


Figure 1 Norwegian Historical Petroleum Production (Source Faktahefte 2012)

The figure above illustrates the petroleum production in Norway measured in standard cubic meters (scm.) of oil equivalents (o.e.), and that it has decreased significantly since the top year 2000 when the production was 181 scm. o.e. Today ten years after the peak, the rate of production is 104 scm. o.e. (www.ssb.no)[1] which is at the same level as in the beginning of the 1990's when the industry was still growing. The drastically reduction in oil production of 43 percent has been compensated with increased production of natural gas. In 2000 the Norwegian natural gas production was 50 million scm. o.e. and in 2010 the production was 106 million scm. o.e. This is an increase that has more than doubled the gas production. Still the increased gas production does not cover the loss of oil revenue because of the negative

[1] http://www.ssb.no/ogprodre/

price gap between the gas and oil. With falling oil production, an increase of just 1 percent more oil recovery is enough to give a gross value increase of 270 billion Norwegian Kroner (NOK, or Euro 34,8 mill.), and that is with an oil price of $70 (report from the Extraction Committee, 2010, p. 17). With today's oil prices around $125 it's quite easy to see that this can generate extra income to Norway and the petroleum companies. The decrease in petroleum production in Norway is due to maturing fields which have reached their production peak and now faces challenges related to immobile oil, reduced pressure in wells, difficult drilling conditions and reservoir mapping. Hence the Norwegian authorities and the petroleum companies focus some of their efforts on increased and enhanced oil recovery (IOR/EOR) through research and development and other efforts that can increase production and exploitation rates of reservoirs. IOR and EOR is ways to increase the recovery of respectively mobile and immobile petroleum by techniques like injection of different compounds into the wells, improved seismic, etc.

While the production has sunk another concern for the petroleum industry is the fact that exploration for new resources have resulted in few and small findings last ten to fifteen years. Thus Norway's gross reserves of oil have not increase significantly enough to get production back to former peak volumes. With small discoveries new challenge related to innovative development have emerged, that is that small fields do not yield enough revenue to support development of technology which is needed to extract the resources. Many small discoveries are also in danger of not being developed because there is no existing infrastructure that they can make us off to make it economical viable, while other small discoveries have to be developed before nearby mature fields with available infrastructure is shut down. Thus there is a time limit for some technology developments as there is a deadline for possible production. In the figure below you can see that the growth of gross reserves has been low since a few years before the turning of the century and has even been negative in a couple of years.

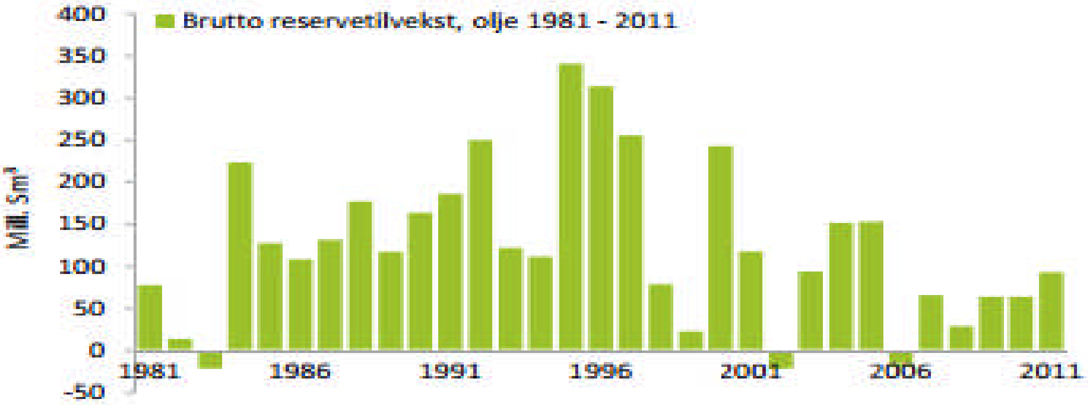


Figure 2 Gross Reserve Growth of Oil in Norway 1981-2010 (Source: Faktahefte 2012)

The biggest add-ons to the Norwegian oil reserves were made in the 80's and 90's and after the year 2000 there have not been any significant discoveries. Much of the reserve growth seen in the figure above is also just upward adjustments of existing fields, and accumulated reserves from many small discoveries. The exploration activity have been high during this period but still with poor results. Then after some 10 years with poor exploration results 2011 turned out to become a very successful year for new discoveries both in the North Sea, in the Norwegian Sea, and in the Barents Sea (www.aftenbladet.no)[2]. Many must feel relieved that their efforts finally are giving results and that they have done things right after all, because the doubt and pressure must have risen as new big discoveries weren't found while the production continued to fall. To most experts surprise the biggest discoveries were made in the North Sea an area that was considered to be thoroughly explored and on the brink of maturation, and not further north in the more unexplored Barents Sea. The amount of petroleum found at the Johan Sverdrup fields in the North Sea is so far estimated from 1.7 to 3.3 billion barrels of o.e. This makes it the third biggest exploration in Norwegian history, and equals 270 - 525 million scm. Another discovery in 2011 was the Norvarg field in the north of the Barents Sea with 225-260 million barrels of o.e. or about 35-40 million scm (www.aftenbladet.no)[3]. This field is not as easy accessible as those in the North Sea as it is located 190 km off the Norwegian coast. Even with today's technology it presents a sizable challenge to extract petroleum resources and sending it through pipelines to shore over such distances. In total 22 new discoveries were made in Norway during 2011 and will be a much needed addition of reserves, but according to The Norwegian Oil Industry Association (OLF) rapport for the petroleum industry in 2011 (economic report, 2011, p. 35); these new explorations in 2011 are

[2] http://www.aftenbladet.no/energi/aenergy/NCS-2011-oil-discoveries-hit-the-20s-2919112.html#.T0U9ufE7ok5
[3] http://www.aftenbladet.no/energi/olje/Norvarg-strre-enn-antatt-2891116.html#.T5VQl6vUP4Y

not big enough to prevent a falling oil production after 2020 so there is still need for exploration efforts in both perceived mature areas and new areas. Such new and attractive exploration areas have and are becoming opened, and one such place is the areas of Lofoten and Vesterålen in the Norwegian Sea where there is believed to be 1.3 billion barrels (206 million scm.) of extractable resources (Geo-technical evaluation of petroleum resources in the sea areas off Lofoten, Vesterålen and Senja, 2010, p. 22). This area is very important to many stakeholders and an area important to other industries and the marine life and wild life. For these reasons there is a huge dispute whether to drill for oil in these areas or not because of perceived high risks. At the moment the Norwegian authorities have decided to postpone the decision till the election year 2013 (white paper nr. 28, 2010/2011, p. 102). When the delimitation agreement regarding the common border with Russia in the Barents Sea was ratified new areas with huge potential have been added to Norwegian territory on the sea border to Russia. Norway started an impact assessment in this region in July 2011when the agreement entered into force. Eldbjørd Vaage Melberg, press spokesperson at the Norwegian petroleum directorate (NPD) stated that the gathering of seismic data will started in 2011 and that this activity that will run until 2013 ending the impact assessment (www.tu.no)[4]. The Norwegian authorities have high hopes that these new areas will reveal major discoveries but the authorities will not have any indications of the potential of these areas before 2013. Thus at the moment no one can say if and how much these areas will increase petroleum reserves. Since the beginning of the Norwegian petroleum adventure production volumes have been rising steadily, but since the year 2000 both the production and reserves have been dwindling due to maturing fields and few significant discoveries. New findings are often located in challenging areas; further offshore (Norvarg) and closer to the foreshores (Lofoten/Vesterålen), in deeper waters, with higher pressure and temperature. In Norway the petroleum companies that operate there have since the beginning relied on technology to discover, extract, develop, and produce products or services that generate income that can surpass the huge running costs involved. The difficult conditions at the NCS have also always been a constant trigger for technology development, and the climate and conditions in the area that is believed to be the future of the Norwegian petroleum industry, the Barents Sea, is much harder than in the North Sea and the Norwegian Sea. Thus technology will play an important role in making future resources located in distant and harsh areas available to the market. It is not even certain that discovered resources can be added to the reserves or put into

[4] http://www.tu.no/olje-gass/article287919.ece

production because inadequate technology, harsh conditions, environmental risks or other issues may hinder operations. The petroleum companies know by experience that technology can help increase efficiency and profits through the whole petroleum value chain, while reducing costs and risks and mitigate many of the challenges they face.

This background illustrates many of the challenges can be solved through technology development, and that these challenges make technology development important in relation to the offshore petroleum extraction at the NCS. Hence both Norway as a country and the petroleum industry is very dependent on a steady stream of technology developments to be able to utilize the natural resources at the NCS and to create as much value as possible from the extractable reserves. Up till now the petroleum industry in Norway have been successful in technology development, but the coming challenges and the advantages of technology development is so important for the future ability to extract petroleum that it is highly relevant to study the whole process.

1.2 Personal motivation

My idea for this thesis came about due to Norway's decreasing oil production, and the fact that the country needs more oil resources to meet future expenditures as the country faces an increase of elderly in the population who needs insurance and care. This combined with the discussion around the opening of the Lofoten and Vesterålen areas made the petroleum industry a very interesting subject for a thesis. In the summer of 2010 I read an article in the local newspaper (www.nordlys.no)[5] in Tromsø. In the article there were an interview with a tunnel expert that mentioned the possibility of drilling tunnels under the seabed of Lofoten and produces the oil through the tunnels, and at the same time mitigating many of the fears and worries stated by stakeholders. The tunnel concept seemed like a very innovative solution that could make these resources available and at the same time silence some of the critics to the petroleum industry by reducing the risks involved. Beforehand I wanted to write a thesis that would increase my knowledge of the petroleum industry, and a thesis with a theme that could be interesting to some of the actors in the petroleum industry. After I presented my motivations for the thesis to my supervisor he led me on the path of technology development at the NCS and I started to research in this direction. After researching the topic I realized that

[5]https://docs.google.com/viewer?a=v&pid=gmail&attid=0.1&thid=12eec128c47929ab&mt=application/pdf&url=https://mail.google.com/mail/?ui%3D2%26ik%3Df3d5edc967%26view%3Datt%26th%3D12eec128c47929ab%26attid%3D0.1%26disp%3Dattd%26zw&sig=AHIEtbR56HzF7rBGwXbjyfLDa_m4oTUd8A&pli=1

the topic was a very good and challenging one; one that is in the daily news almost every day, and that would enhance my knowledge with interesting data. By that the topic was chosen.

1.3 Research Questions and Contribution

Based on the background and my personal motivation the thesis is designed to explore technology development at the NCS with attention at characteristics of institutionalized solutions/choices that are part of this process. When a problem interferes with operations a need for technological development is created. Planning and developing a technological product includes many small factors that together makes up as process. After the product is finished developed it has to be marketed and made commercially successful. Each actor has their own motives and possibilities to be part of technology development but in many cases cooperation and joint efforts are crucial. I therefore also found it interesting to explore different stakeholders and how they work alone, or together with other corporations in this process. This led me to formulate the following research questions:

1. *How is technology development carried out at the NCS?*
2. *What characterize the institutionalized solutions that make up the process?*

Regarding the first research question the initial stages, including qualification, the aggregated data illustrate how the execution is at the NCS and emphasize obstacles or problem areas that the petroleum industry and authorities should be aware of. The second research question is related to institutionalization and is more complex since there are many aspects to institutionalization at the NCS. The process at the NCS unfolds in a certain way and institutionalized solutions and choices that are made 'standards' can help explain how and why things are the way they are. In this thesis institutionalization is used in three ways to describe; the fixed framework that surrounds the petroleum industry, the institutionalized process of technology development at the NCS, and institutionalization of the outcome of the process. The latter means technology developments that are the end-result of a technology development process, and which after development goes through critical phases that will decide if the technology becomes diffused and commercially successful. It is a theoretical discussion where the NCS is connected to issues in the theory that point to factors to that slows down technology development from being successful diffused and commercialized. In order to do this study I have taken starting point in three theories that I found relevant to the research objective and which can contribute to find the answer to these research questions. The chosen theories have within them models and other features that I have made use of in the making of this thesis, which will be further explained in chapter two.

A study carried out at the University of Nordland in 2010 has also looked into technology development at the NCS where the focus was the industry's general attitude to new technology development. My study differs from this in that study how technology development is carried out and diffused at the NCS by describing the stakeholders and their role in a development process, by examining crucial parts of the institutionalized process of technology development, and by examining important factors in the process of making a product become and stay commercially successful. The contribution of this study is that it is a thorough review of important aspects of the petroleum industry in Norway in relation to technology development. One get updated information on the petroleum industry and technology development efforts by reading this thesis and it will thus give the reader fresh data and better understanding of important processes. Areas that need improvement and that obstruct technology development and diffusion at the NCS will be highlighted, but at the same time I expect to find elements that point to fundamentals of success at as well. Therefore this thesis will be interesting reading material for the petroleum industry, authorities, and other stakeholder of the petroleum industry in Norway. The empirical data will be analysed with the already mentioned theories in mind, and parallels to the NCS will be discussed therefore the thesis should also be of interest to students, scholars, and researchers that have an interest in petroleum matters and theory. Hopefully this thesis can inspire and trigger ideas for further research within this topic and/or chosen theories.

1.4 Limitations

This thesis will explore technology development at the NCS, and institutionalization solutions in regards to the process. The petroleum operations are divided into several phases; the upstream, the midstream, and the downstream phase. This thesis will only deal with technology development related to the upstream phase and that are developed for petroleum companies as end-users.

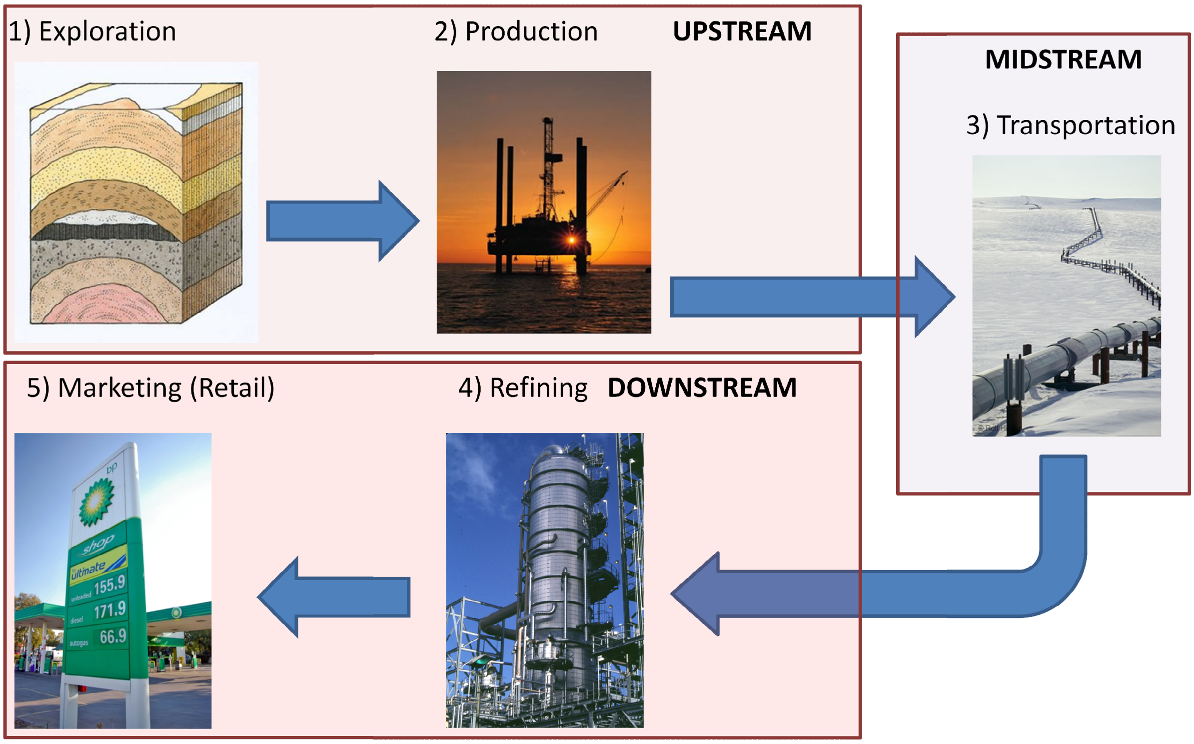


Figure 3 Phases in the Petroleum Value Chain (Bodgdan, Volostrigov, 2011)

As seen in the figure above the upstream phase include both exploration and production operations of petroleum offshore at the NCS, both will be considered. In the innovative theory there is a model for the development process and to limit the scope of this thesis I have chosen to disregard any information in regards to the last stage of 'consequences'. I have chosen to collect interview data from six respondents only, by telephone. All limitations are made to limit the scope of the thesis, to save costs, because of limited timeframe, and because of availability of respondents and data.

1.5 Structure of the Thesis

The structure and build-up of this thesis follows the standard requirements the University of Nordland sets for these kinds of reports. The thesis starts off with an introduction which covers the background for the thesis topic, why the topic is up to date and relevant, and my personal motivation, and research questions. The second chapter presents the relevant theories that are relevant to the topic and the thesis's objective and which have helped structure the thesis, collecting relevant data, and explain my findings by identifying the major mechanisms that are at play. In the third chapter the methodological choices made are clarified, before the fourth chapter presents the empirical data from both first and secondary data sources. In the analysis in chapter five empirical findings will be viewed in relations to relevant theories and the research questions, before a conclusion of the thesis is introduced in chapter six.

1.6 Further Research

During the making of this thesis I have come across many ideas for further research that could be interesting for next year's students, all of which is related to technology. The most interesting finding in this thesis is related to qualification of technology that deserves isolated exploration. The report from the extraction committee (2010, p. 46) mentions a term called "the valley of death" illustrating that it is a long period of time before qualified technology and tested international technology is utilized at the NCS, so it would be interesting to also take an isolated look at the implementation of technology. Further in one interview it was suggested that it would be capacity problems if they increased their funding, it could be interesting to find out if research institutes and universities have the enough good projects that defends receiving more funding? The last idea for further research is related to the Norwegian technology clusters and could be related to their success and the local geographical phenomena that have happened in several different pa in Norway. Why are they so successful? How does it spread to the near geographical surroundings?

2. Theoretical framework

2.1 Innovation Theory

When a petroleum stakeholder at the NCS decides to make technological change(s), they will start a process that helps them work in an effective way to implement the change. The innovation theory describes a process of innovation from the first stages of recognition of a need/problem and an idea to solve it, to the last stages where the innovation is spread and results and consequences are evaluated. This is a process that is more or less universal, but in different industries or businesses the process is likely to have differences or adaptations to special conditions. Further the theory mentions that all innovations have a beginning and an end, and that adoption of this innovation is related to technology performance.

2.1.1 What is an Innovation?

The definitions of the term innovation are many, but they all have a relative similar essence. A definition by Rogers (2003) states that an innovation is an idea, practice, or object that is perceived as new by an individual or other units of adoption. But this is still too elusive and needs further description. Fagerberg et al. (2009) states that; an innovation is a cumulative phenomenon. It builds on existing knowledge, including past inventions and innovations, while at the same time providing the basis for new innovative activity in the future (Fagerberg et.al. 2009). Economist Joseph Schumpeter was the first to draw the distinction between 'invention' and 'innovation'. According to this distinction, invention is a new combination of pre-existing knowledge, whereas innovation is more subtle concept. If an enterprise produces a good or service or uses a system or procedure that is new to it, it makes an innovation. In this view, invention – if present – is part of the innovation (Narayana, 2001). Viewed this way, an innovation includes both:

- A change new to both enterprise and the economy
- A change that has diffused into the economy and is adopted by the firm(s)

These two points' shows how much impact the 'change' needs to get in order to be classified as an innovation. If the changes are of such a magnitude as the two points mentioned above then it constitutes an innovation. Based on the definitions of innovation it's apparent that to be part of an innovative endeavour you can have an invisible idea, a process or way of doing things or it can be a product that is tangible. Either you have a tangible product or invisible service, common for both are that they are meant to solve a certain problem/need in a manner that is superior to the previous solution. It is often a perception that innovations have to be perceived as new, but it matters little whether or not an idea is ‘objectively’ new as measured by the laps of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If an idea seems new to the individual, it is an innovation (Rogers, 2003).

2.1.2 The innovative process

Innovations rarely just happen out of the blue and normally there is a process that helps organizations to work in a structured way to accomplish their objectives. In the innovative theory there is a model for the innovative process and the figure below illustrates the six phases in the innovative process developed by Rogers (2003), which is referred to as the linear innovation model.

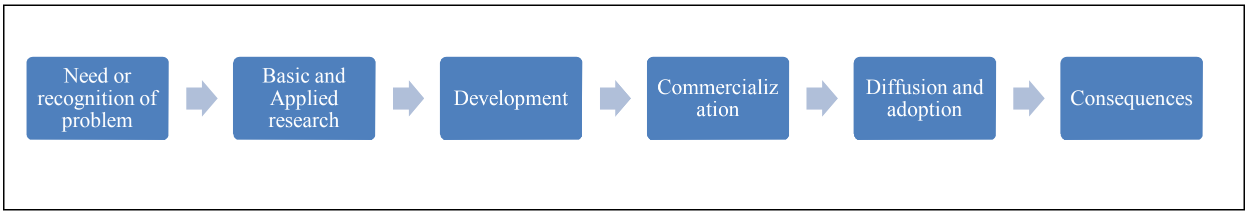


Figure 4 Phase’s in the Innovative Process (Source: Rogers, 2003)

A competing model is the interactive innovation model that has directed critics of the linear model about it being to general and unrealistic, that not all stages are always used (e.g. research, commercialization, evaluation), and that loops between some of the stages is destined to happen and is absent in the linear model. It is true that for some innovations not all stages in the linear model are always necessary and in some cases redundant stages are simply skipped. However I need to examine all stages and any additional stages that might be special to the Norwegian petroleum industry. The critic concerning absence of loops between stages is not important to this study because the theory is in part used to become aware of important aspects to explore, but if loops occurs at the NCS I will make sure to highlight it. One thing that acknowledges the use of the innovative process is that the simple version of the interactive model is similar to the stakeholder model and therefore factors missing in the innovative process, but present in the interactive model, will be covered by stakeholder theory. Further and according to Isaksen (1999) the interactive model is a tool for analyzing innovative processes in low research & development intensive industries and small businesses, and thus seem not to be well suited to the petroleum industry at the NCS. As I didn't know the petroleum industry very well beforehand I was interested in a model that could help illustrate stages or phases that companies may have to consider and work through, and the linear model have just that, and since the critic of the model is not relevant here it was therefore preferred in the end.

The recognition of a need or a problem is the first stage of the process, and the motivation of those involved is that they want to solve this need or problem. In the scope of this thesis the recognition of a need or problem might come from the field operators, the Norwegian authority, or other actors at the NCS. Stage two and three are what theory calls the conversion stages with important efforts that lead to the desired solution or product, were the companies will develop and find solutions through careful planning and intense testing etc. The product is finished and utilize by a petroleum company if they have developed it themselves, or it can be a contractor (developers, suppliers, and service companies) who have responded to a request from a petroleum company and that have developed the product to them. Anyway the developer of a product would at this stage want to commercialize it by creating awareness amongst potential consumers and getting the initial sales. The fifth stage is about diffusion and adoption of the product. Diffusion is the process of which news of a product is distribute through communication channels over time among the members of a social system (Rogers, 2003). The company who created the product may use it themselves, but they may also want to earn additional profit by selling the technology to others. Companies will almost always try to get acceptance for their product and try to spread it in every direction since this lead to higher income for the innovative company. And as we shall see in the next sub-chapter; the better the performance of the product are, the higher adoption rate. The last stage is where the output and the whole process are evaluated and measured against earlier performances and expected result. Unfortunately in the petroleum industry this is easier said than done since it can take many years before one can see any results of development projects and it can even be difficult to make measurements of performance or point to certain areas that need improvement.

2.1.3 Technology Evolution

Once the product is developed and presented to the market, its evolution follows a reasonable stable pattern when it takes off and becomes commercially successful. This stable pattern of the innovations life-cycle is according to all theory shaped as an S-formed curve. According to Narayanan (2001) technology evolution refers to changes in performance characteristics of a specific technology over time. The S-curve represents and shows both the innovations development over time in relation to performance, and its shows adoption rates. The connection between the two is that adoption rates are dependent on improved innovation performance during its lifetime. This correlation is natural because good quality products attract more customers. The beginning of the S-curve represents the birth of a new market opportunity and development of a product, while the end of the curve represents death, or obsolescence of the product. The end of one S-curve also marks the emergence of a new S-curve – the one that replaces the current. In the figure below the x-axis represent product performance in A and adoption rate in B, while the y-axis reflects time in both A and B.

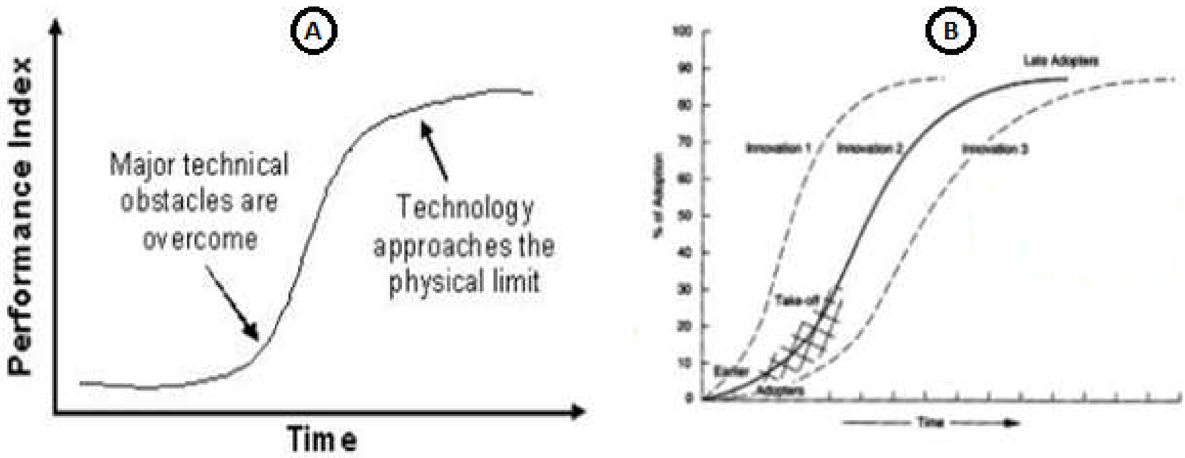


Figure 5 the S-Curve, Evolution and Life-cycle of Innovation (Rogers. 1995)

During the initial market release of a new technology product, according to the theory, the performance characteristics show very little improvement and adoption is limited to a small group of early adopters and small niche markets responding to a need or a problem. This is followed by a phase where the technology product shows rapid improvements in performance at an accelerating tempo, attracting additional adopters and thus winning higher market share. In the next phase the performance is flattening out and the before considered 'new' technology has now reached its maturity and further improvements become very difficult to achieve, therefore the amount of adopters are also flattening out and only a few late adopters are now acquiring the technology. If newer products are introduced to the market consumers will quickly shift and the new product will start eating market shares and replace this now old and mature product. But the consumers will only shift from old to new if the change includes an enhancement in performance beyond current levels.

2.2 Theory of Institutionalization

The theory of institutionalism has a wide variety of viewpoints amongst the researcher and deals with the organizational changes and how they happen. Organizational change is the change in formal structure, organizational culture, goals, program, or mission (DiMaggio and Powell, 1983). This definition is interpret to apply to technology and is within the scope of the petroleum industry that is always on the lookout for new ways to regenerate themselves technologically in order to increase their margins in a cost intensive industry. One perspective of institutionalization is that of 'Institutional Isomorphism' that deals with organizational change that leads organizations to become more similar to each other. Another perspective is the 'Institutionalization of Institutional theory' which covers the process of institutionalism; from changes in organizational structure and the path towards acceptance and diffusion of these changes until they are perceived as standard or natural.

2.2.1 Institutional Isomorphism

There are two types of isomorphic change; competitive and institutional. DiMaggio and Powell (1983) cover institutional isomorphism with its three mechanisms of institutional change. This view deals with the observed fact that organizations within the same organizational field often changes to make the organizations more similar without necessarily making them more efficient (DiMaggio and Powell, 1983). Most corporations do not wish to change unless it can enhance their performance, and thus in the context of the petroleum industry such changes are considered to be part of the host-country's framework that the stakeholder of that industry have to comply with. An organizational field are organizations that, in aggregate, constitute a recognized area of institutional life (DiMaggio and Powell, 1983). The initial organizations motive for change is triggered of a problem or need. But the later adopters of change are often driven by other motives such as becoming more similar so they are perceived as equal to organizations in their industry. According to DiMaggio and Powell (1983) highly structured organizational fields provide a context in which individual efforts to deal rationally with uncertainty and constraint often lead in aggregate, to homogeneity in structure, culture, and output. To describe this process of changes in organizations within the same organizational field DiMaggio and Powell (1983) use the theory of isomorphism. The three mechanisms that explain the organizational changes are coercive, mimetic, and normative isomorphism. This model take into account the vast environment the organizations have around them and the pressure each company experience from their environment.

2.2.1.1 Coercive Isomorphism

This type of isomorphism, as the name implies, has to do with forces of firm persuasion or collusion and is coming from the organizations external environment. The organizations have to comply with this external pressure if they want to keep their current position in the organizational field. This external pressure forces organizations, in the same organizational field, hit by the same pressure, to conform to certain 'standards' which in turn forces all organizations to change, and thus become more similar. In the context of the Norwegian petroleum industry the authority is an example of a very dominant power that can set the agenda for companies that operates at the NCS. The authorities have built up the industry in collaboration with petroleum companies, and the influences at their disposal (finances, laws/regulations, etc.) makes them capable of setting premises for the rest of industry. The authorities thus influence other stakeholders to comply with their premises but within limits. Laws and regulations regarding the petroleum resources in Norway and their content have not been investigated in the work of this thesis, but are merely acknowledged as being part of the framework for the petroleum industry.

2.2.1.2 Mimetic processes

Mimetic behaviour is about how organizations change in reaction to uncertainty by modelling themselves on other organizations. Uncertainty can be ambiguous goals, poorly understood technology, or other uncertainties created in the environment around the organization. Instead of finding the solution to this uncertainty internally, the organization turns to competitors or companies with similar attributes as themselves. The mimetic processes is a form of benchmark of best practice, were the organizations copy other organizations who they have found to have better solution to the perceived uncertainty. The organization that copies other companies reaps the advantage of saving costs, e.g. now unnecessary research and development. One example on how this might appear on the NCS is if one petroleum company wishes to adopt another petroleum company's technology to use in their own operations. If the mimetic process occurs at the NCS and a company or a group of companies model themselves after ‘the best in the market’ it seems only naturally to expect it to result in an industry where many of the same solutions are chosen by different stakeholders.

2.2.1.3 Normative pressures

The third mechanism is the normative isomorphism which stems from professionalization of managers and specialized personnel of large organizations. Professionalization is interpreted as the collective struggle of members of an occupation to define the conditions and methods of their work, to control ‘the production of producers’ and to establish a cognitive base and legitimation for their occupational autonomy (DiMaggio and Powell, 1983). There are two aspects of professionalization to organizational change. The first being formal education and legitimating which explains how the professionals, through the universities and professional training institutions, learn the normative rules about organizational and professional behaviour that is to become expected of them by their future employer. The second aspect is the professional networks that connect managers and specialized personnel in different organizations with one another for sharing of valuable information and experiences. Both of these aspects make the organizations more similar to one another. Companies tends to hire professionals and specialized personnel that have similar background and experiences, that the universities and other learning institutions provide, which enhance the effect of organizations becoming more uniform. When organizations in a field are similar and occupational socialization is carried out in trade associations, workshops, in-service educational programs, consultant arrangements, employer-professional school networks, and in the pages of trade magazines, socialization acts as an isomorphic force (DiMaggio and Powell, 1983).

2.2.2 Process of Institutionalization

The second perspective is the process of institutionalization presented by Tolbert and Zucker (1996), which explains the process from when a change occur to the change becomes the norm and adopted by most participants in the same organizational field. In an organizational field changes happens all the time. This model try to explain how and why some changes gain acceptance and is adopted by the majoriety of the companies. The model is stated to be most applicable to societies that are characterized by relatively weak national states, which is not the case in Norway. Still I have chosen to use this model because it contributes with many important and interesting aspects and have similarities to parts of the innovative process.

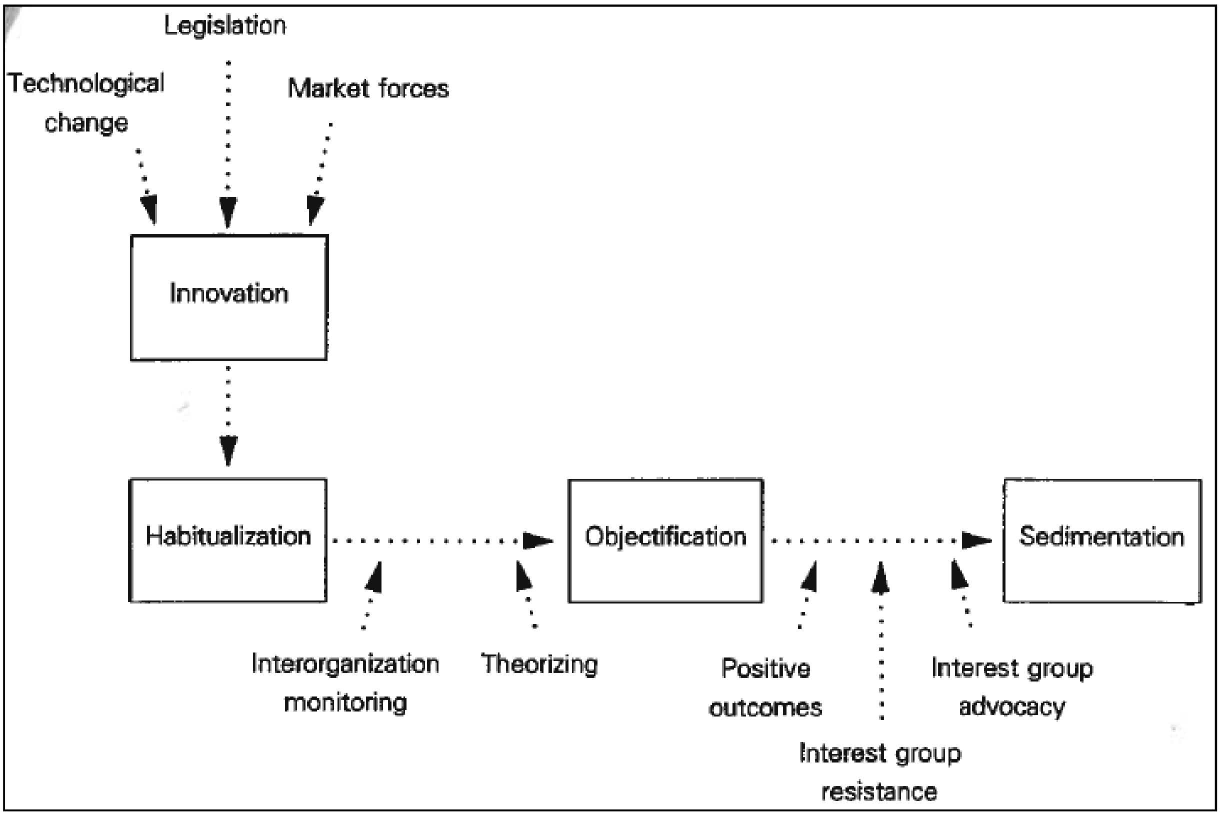


Figure 6 Component Processes of Institutionalization (Source: Tolbert & Zucker, 1996)

The theory is about how a organization, or a set of organizations, feel a need to change their structures, culture, production rutines, or the like. This change in organizational behaviour have been developed empirically and adopted by an actor or set of actors in order to solve recurring problems (Tolbert and Zucker, 1996). The causes for the change is illustrated in the top left corner of the figure above; new technology can become available or provide a new technological innovation that allows the organization to change some processes to the better. Secondly there can come new legislative regulations from the (host) government that organizations have to conform to and thus adapt and change. Thirdly but not least the market forces affects an organization in its dayily business. The market forces can make an impact in many ways and at the NCS it can be related to tanker/rigg rates, dollar value, interest rates, etc. In general it can be said that market forces disturb the status quo and the organization is forced to change to obey the revisions of the market or to keep up with the rest. This internally or externally induced pressure 'forces' the organization to change in a way that is percieved as innovative. When some organizations make changes others will not neccecarilly follow automatically and in the following sub-sections the stages of habitualization, objectification and sedimentation will be reviewed in order to explain the processes that are innvolved when changes are spread from one organization to others within the same organizational field.

2.2.2.1 Habitualization

In an organizational context the process of habitualization involves the generation of new structural arrangements in response to a specific organizational problem or a set of problems, and the formalization of such arrangements in the policies and procedures of a organization, or a set of organizations that confront the same or similar problems (Tolbert and Zucker, 1996). In this stage the change or adoption is largely a independent activity and the number of organizations that adopt to these structural changes are few, and the manner they chose to implement them may differ amongst them. Adoption at this stage is predicted by characteristics that make a change technically and economically viable for a given organization and by internal political arrangements that make the organizations more or less receptive to change processes (Tolber and Zucker, 1996). Outsider organizations who do not have regular interaction with the adopting organization(s) are often quite unaware of the implemented solutions. There may be multiple adopters at this stage but they are few in numbers and most likely face similar circumstances that makes them prone to find the same solution, thought the implementation and usage may vary largely. Adoption is in sum explained by oppertunety and feasibility of change, and the organizations internal perception of uncertainty and risk in relation to change. At the NCS habitualization is about how the petroleum industry stakeholders alone or in few numbers have to make changes due to challenges that interferes with their operations, implementing and thus formalize the chosen solution.

2.2.2.2 Objectification

In this next stage the change has over time recieved some recognition and more organizations adopt to the solution in what is called the semi institutional stage. Objectification involves the development of some degree of social consensus among organizational decision-makers concerning the value of a structure, and the increasing adoption by organizations on the basis of that consensus (Tolber and Zucker, 1996). Under these circumstances managers in more and more organizations get their eyes open to this new structural change and find it to be of value. Diffusion can sometimes be spearheaded by what the theory referres to as a 'champion', which is someone that has a material stake in promoting the struckture. To be successful in promotion the product the champion must succeed with 'theorizing'; making potential customers see that this product is the solution to their problems. Managers can find a structure valuable by carfully monitoring the market and their competitors, and expecially those who have implemented this change allready. They can simply imitate and copy competitive adopting organizations, reassured by success of other adopting organizations. The logic is that if the change is proven valuable to similar organizations, the change should also be of value for them. Its easier and more cost effective to adopt someone elses innvention than trying to develop your own copy, and the more organizations that adopt it the safer the change is percieved by outsiders. Even though at this stage the structure has recived recognition and is more widly diffused some potential adopters will still be sceptical and may opt for their own tests to evaluate the changes value to the organization. Hence decision makers use information aquired from observing the market, evaluating choices of others, as well as their own subjective assessments, to determining if change is the best choice for their organization.

2.2.2.3 Sedimentation

Full institutionalization involves sedimentation, a process that fundamentally rest on the historical continuity of structure and especially on its survival across generations of organizational members (Tolbert and Zucker, 1996). This means that the structure is spread wide to all potential customers and that the usage is deeply rooted in each organization utilizing it. Tolbert and Zucker (1996) identified factors that affect the extent of diffusion and long-term retention of a structure as they saw it as key to understand the sedimentation stage. One such aspect that could truncate sedimentation is that interest groups collectively can mobilization against the structure. The second is that the structure will not be long enduring if it cannot display good results, and that customers are likely to abandon old arrangements over new and promising structures if that happens. Thirdly and last it is vital for the endurance of the structure that it has its own interest group that advocate for continued use and thus survival of the structure and in this way resists 'negative' interest groups. This also ensures continued cultural support of the structure. At this stage the structure is practically fully diffused and utilized by the majority that is viewed as potential customers. The structure has proven its durability and value to other organizations so new customers are easily adapting the structure with little or no doubt, individual tests or calculations.

2.3 Stakeholder theory

In the modern world businesses and business relations have become more complex as organizations and companies have changed dramatically over the last 20-30 years. Simultaneously our understanding of our environment and variable that affects it has grown. The basic idea of stakeholder theory is that business can be understood as a set of relationships among groups that have a stake in the activities that make up the business. Business is about how customers, suppliers, employees, financiers, communities, and managers interact to create value. To understand business is to know how these relationships work (Freeman et al, 2007). Thus organizations that want to be successful and achieve their goals (create value) need to know all their stakeholders and their relationship and interest to the business of the corporation. Stakeholder theory attempts to explain and guide the operation of the running corporation, viewing it as an entity through which multiple and not necessarily overlapping purposes are pursued (Hurst and Viber, 2004). Said in other words; stakeholder theory attempts to guide the organizations in their multiple business goals in relations to multiple stakeholders that have an interest in their business. One important contemporary challenge for manager is to achieve organizational goals while at the same time meaningfully addressing the concerns of their stakeholder and maintaining an advantage over competitors (Donaldson and Preston, 1995).

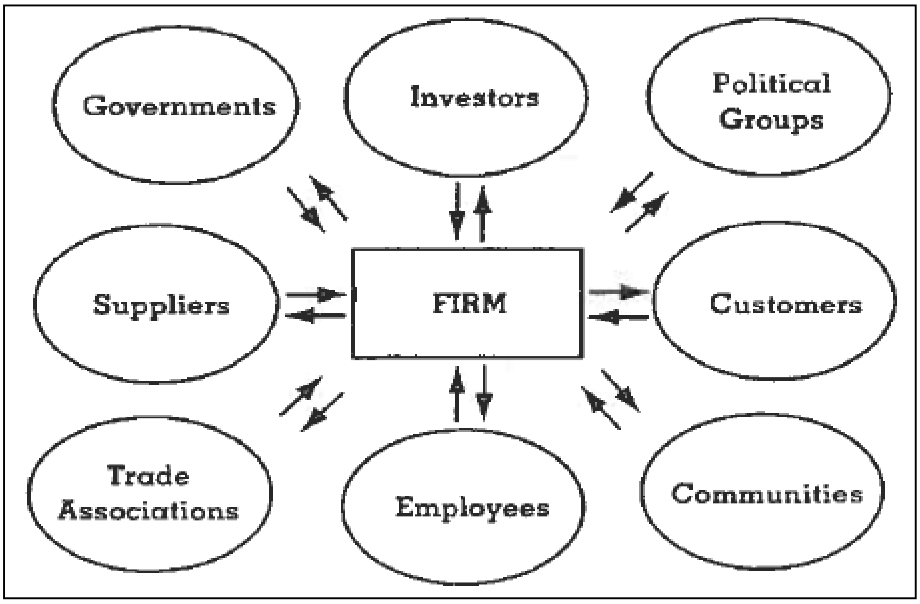


Figure 7 the Stakeholder Model (Source: Donaldson, T., and Preston. L. 1995)

As with other theories, the stakeholder perspective has numerous versions credited to it (Donaldson and Preston, 1995). In the figure above a model of a wide stakeholder definition and its complexity is shown. As illustrated all the stakeholders are grouped around the organization and arrows indicate that they have a two-way interaction with each other. The stakeholder approach can either be an ongoing process or just started in response to an impact to, or by the corporation. In any case organizations have to map and categorize stakeholders, estimate their power, and impacts to them. Thus stakeholder mapping can remind of a kind of due diligence and can be as deep and comprehensive as the corporation wish, and still one would rarely feel confident enough about the information that is collected. A corporation can always know more about possible positive and negative impacts that might hit the organization and stop them from accomplishing their goals. According to Hurst & Viber (2004) stakeholders are defined by their legitimate interest in the corporation, not the corporation's interest in them. But a even more accurate definition states that; any identifiable group or individual who can affect the achievement of an organization's objectives or who is affected by the achievements of an organization's objectives are to be seen as stakeholders (Freeman & Reed, 1983). Technology development in relation to the petroleum industry in Norway is a prolongation of the industry and hence stakeholders of the petroleum industry and stakeholders of technology development are considered to be the same stakeholders in this study. In the empirical chapter I have borrowed and slightly redefined the original stakeholder figure by placing technology development in the centre. Thus the stakeholders are viewed from the perspective of interdependent interest and involvement (role) in technology development in the Norwegian petroleum industry. With this adjustment the case of study in this thesis is the process of technology development and not one specific company. Technology development is the activity that can be understood as a set of relationships amongst groups of actors that have a stake in the petroleum resources at NCS, and how they interact with each other to create value of these resources.

2.4 Summary of Theories

In the technology development area within the petroleum industry there is a wide array of theories and models that are at play and that could have been used instead of the once utilized in this thesis. The choice of theories is decisive for the content and structure of the thesis in the sense that different theories will lead you to examine different areas of the topic that you are studying. Different theories emphasize different aspects and from different perspectives when they try to explain occurrences. In this thesis the theories that are chosen are closely connected with the research questions and factors that I perceived as important to explore in order to be able to solve the research questions. The collective explanatory power in some of the theories has been decisive in the choosing and usage of these theories. Other theories that could have been relevant have been left out because of limited time to review all of the possible theories. In this thesis the stakeholder theory helped identify all relevant stakeholders and interpret their affiliation with the technology development processes and sort them into manageable groups. Thus it has functioned as a structure for getting an overview of the industry, the actor's role, and how the actors contribute to the process of technology development. In the figure below the used theories and their shared influence over the topic in this thesis is illustrated.

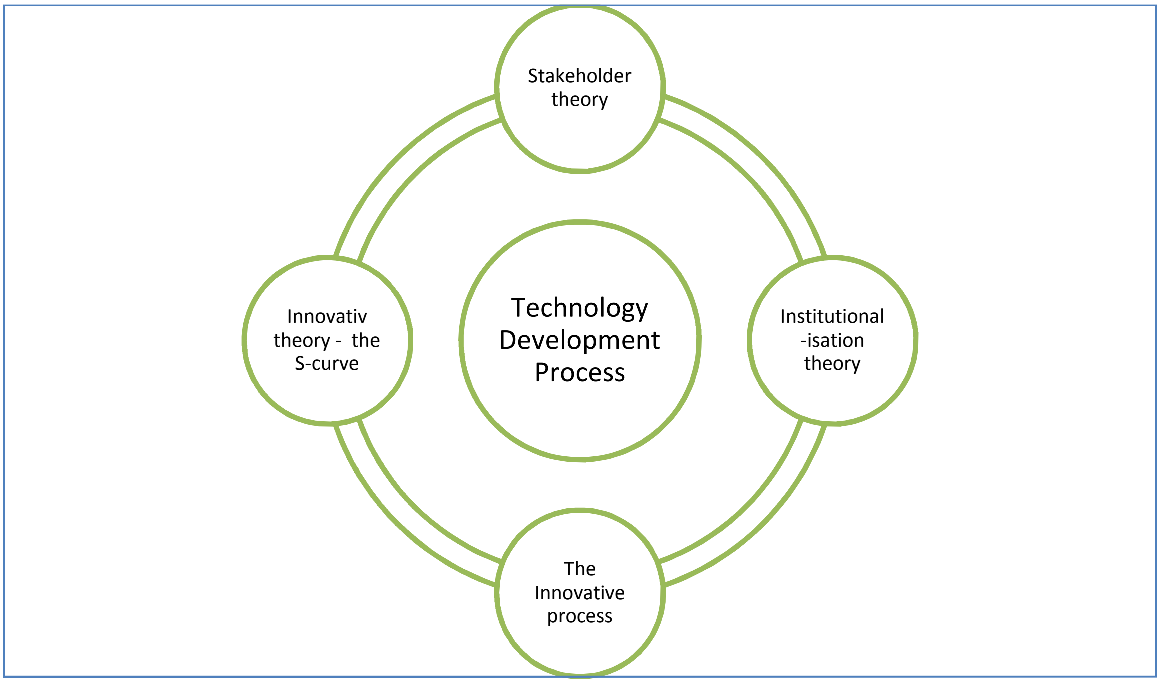


Figure 8 Theories utilized and Shared Influence over the Technology Development Process

The innovative theory is used for all its phases that are very much relevant to technology development process. The innovative process was also used as basis for structuring the interview guide and also provided essential definitions that are important to have clarified. Isomorphism explains how constraints works as a framework that forces organizations to change in ways they would not do if they could chose. Furthermore the S-curve of innovative theory has some explanations in relation to the levels of adoption in conjunction with an innovations performance over time. The process of institutionalization is used because it helps explain which mechanisms that are in play from when an need occurs to a solution is created and diffused, and in the end becomes the norm for solving a specific challenge. In sum the theories help explain how the technology development process unfolds at the NCS, by looking at institutionalized solutions, and which stakholders that contributes, with what where, in the prosess.

3. Methodology

This chapter explains choices I have made regarding thesis design and the direction this has lead me in, in relation to structure of the thesis. By reading this chapter you will learn that the chosen design is an exploratory case study shaped to collect rich qualitative data concerning technology development process at the NCS through semi-structured interviews and secondary sources. Further this chapter discusses important elements of sampling and explains why my six respondents divided onto five stakeholder groups are considered a good sample size. Explanation of how the data has been analysed is followed by an evaluation of the validity and reliability in this thesis, before the chapter ends up with ethical considerations that had to be considered and addressed.

3.1 Research Design

The research design is about how one chose to organize the research, including colleting of data and ways to analysing data in a manner that best answers and explains the research questions. According to Ringdal (2007) there is mainly three types of objectives in a research project; explore, describe or explain. This thesis's objective is to explore technology development at the NCS, taking starting point in the innovative process and stakeholder theory. While I have explored into the development process the focus has also been on institutionalization, that is to explore state of affairs and understand why things are the way they are. I have chosen to use a case study where the unit of analysis is technology development at the NCS. The case study method is defined and understood in various ways and according to Easterby-Smith et al. (2008) a case study looks in depth at one, or a small number of, organizations, events, or individuals, generally over time. According to Berg (2009) a case study involves systematically gathering enough information about a particular person, social setting, event, or group to permit the researcher to effectively understand how the subject operates or function. Because of my exploratory objective and that these and other descriptions of case studies fit with what I had in mind I am convinced that an exploratory case study is the best research design for this thesis. An exploratory study objective is to gather as much relevant data as possible and get as much knowledge out of it as possible, which sometimes can result in quite 'open' or 'wide' problem statements or research questions like this thesis, but it comes natural of the objective of the thesis.

3.1.1 Qualitative Research Design

There is an important distinction between qualitative and quantitative research design. The former involves collecting data that is mainly in the form of words and the latter involves data which is either in the form of, or can be expressed as, numbers. The researcher has to make a careful and deliberate choice as to what form his data should have and what is most appropriate data form to answer the problem statements. And even the problem statement will be formulated differently depending on if methods and data are of qualitative or quantitative nature. In studies with a quantitative touch it is common to use hypothesis, while qualitative studies form problem statements as questions. Hence this thesis uses research questions. Researchers can choose between these two methodologies or a combination of both, but as this thesis' is designed as an explorative case study it is appropriate to collect qualitative data in form of words to get as rich and informative data as possible. Qualitative and quantitative methods can be used fittingly with any research paradigm (Denzin & Lincoln, 1998). Looking back history of research is bursting with positivistic and quantitative research methods much because sciences like math, physics, and biology were established before social science. In recent years, however, strong counter pressures against quantification have emerged through social constructionism and other paradigms. According to Denzin & Lincoln (1998) this counter pressure focuses on the exclusion of meanings and purposes in quantitative studies. Quantitative research function well in some studies, but some of its weaknesses is that it can be inflexible and is not so good for the purpose of generating meanings and understanding. The use of qualitative research on the other hand will often give a greater depth of understanding (Berg, 2009). This confirms that the use of qualitative methodology is the appropriate design for this thesis since the objective of this thesis is to acquire understanding and generate knowledge.

3.2 Data Collection

The primary data contains of recorded telephone interviews transcribed into text and the secondary data is also mostly in textual form, with the exceptions of an excel file containing numbers of authority funding of petroleum research. Both primary and secondary data have required different methods of data collection and the results from each source have then been put together and analysed in the context of the research questions.

3.2.1 Primary data

Primary data or empirical data is collected by the researcher him- or herself. According to Easterby-Smith et al. (2008) collecting one's own research data gives control over both the structure of the sample and the data obtained from each respondent. This gives greater confidence that the data will match the study objectives. Collecting one's own data also has its disadvantage as it can be both a very time consuming and a costly affair. To circumvent some of these disadvantages I have conducted the interviews through telephone which has saved me both time and costs of travelling to the respondents. I also suspect that it is much easier to get respondents to participate if they know that it is just a telephone interview with a beforehand agreed time limit. Time used to transcribing the qualitative data is an obvious disadvantage of collecting qualitative data one one's own, which I experienced firsthand as the time saved on telephone interviews was spent on transcribing interviews. I believe that it is a good idea to transcribe the interview as soon as possible after they are done while the interview is still fresh in the researcher's mind. If the researcher are conducting several interviews in one day this could be difficult to manage. Bad sound quality is a risk and a disadvantage with recording interviews as it sometimes can be difficult to hear what is said on the recording. There are a number of reasons to why this can happen, like that the respondent talks low, background noises interfering, dialect and language issues, low or empty battery, etc. Transcribing the interviews right after the interview will help the quality of the data in such cases since it is easier to record the data accurately because you still remember the conversation. In almost all interviews I did there were moments where I had doubt to what was actually being said when I was listening to the recordings. My experience is that this is something to be aware of and that happens at some point in almost all recorded interviews no matter how good quality of the recording. Another disadvantage of telephone interviews can be that you only have data in the form of words, and you miss the body language, facial expressions, clothing style, etc. which could provide additional information to the data set.

3.2.2 Secondary data

Secondary data already exists and is gathered from free sources or bought from research institutes and the like. This can be governmental documents, public or private databases, reports, articles, internet sites, annual reports, etc. The obvious advantage of using secondary data is that it saves the researcher both time and money so that he can get up to date on already produced research and the topic in general. According to Easterby-Smith et al. (2008)

the downside of using secondary data sources it that the quality of the data may be more uncertain, and the researcher does not have control over either the sample or the specific data collected. The secondary data made use of in this thesis is for the most part official reports and other data from official sources about the technological situation at the NCS, hence I feel very confident regarding the quality. The data has contributed with background information and valuable knowledge that was important to acquire before I could started to think about doing interviews. Besides the theories in chapter two this backdrop of knowledge in form of secondary data has helped me to get acquire a base of knowledge that further lead me to find important research elements and relevant topics for the interviews.

3.2.3 Semi-structured interviews

Because of the objective and chosen research design interviews were considered the most appropriate data collection method for this thesis because it supplies rich textual data. The first thing I had do decide upon was how much structure I would have in the interviews. According to Easterby-Smith et al. (2008) there are three main types of interviews related to structure; highly structured, semi-structured and unstructured interviews. Again the purpose of the research would direct the researcher towards what is most appropriate structure of his or her interviews. Highly structured interviews are best suited for market research, polls, taste etc. where the answers in general are short. This kind of interviews is also good for producing quantitative data, and do not fit well with my research design. According to Easterby-Smith et al. (2008) Interviews, both semi-structures and unstructured, are appropriate methods when:

1. It is necessary to understand the constructs that the respondent uses as a basis for his or her opinions and beliefs about a particular matter or situation
2. The aim of the interview is to develop an understanding of the respondent's 'world' so that the researcher might influence it, either independently, or collaboratively
3. The step by step logic of a situation is not clear; the subject matter is highly confidential or commercially sensitive; and there are issues about which the interviewee may be reluctant to be truthful other than confidentially in a one-to-one situation.

All of these terms and conditions are present in my study, and in the end I chose to use semi-structured interviews. I have a conviction that semi-structured interviews are better than unstructured interviews for this study, because it gives me more control over the interview situation and the topics that I want to cover. This means that instead of letting my respondents' just fire away on technology development at the NCS I made an interview guide or a topic guide before I started doing interviews. In the interview guide I have four main topics that I wanted to discuss. Under each topic I had made three-four questions that I initially felt were necessary to touch upon, while the rest of the information would come from the respondents association with the topics and my open questions. I had made sure that I had weeded out questionnaire errors and asked questions in an order that would let the interviews progress in logical fashion. After a few interviews the main topics were still intact but I soon realized that the answers to my 'support' questions were identical independent of respondents. As my knowledge grew I gradually started to ask new relevant questions off the top of my head and I asked follow-up question when I felt that I needed additional information or when something was unclear. As the data collection progressed and interviews were undertaken I felt more confident about the topic and what I wanted to know. Hence not all respondents got the exact same questions as I adjusted my questions to the respondent's roles and function and what I already knew and needed to know. All in all I feel that I managed to create an interview situation where the respondents felt comfortable and provided me with lots of relevant and accurate data.

3.2.4 Sampling

In order to be able to make inference about technology development at the NCS one need to collect data from organizations and people involved in this process, and in this study the whole population are organizations involved in the petroleum industry in Norway. The term population refers to the whole set of entities that decisions relate to; while the term sample refers to a subset of those entities from which evidence is gathered. The inference task then is to use evidence from a sample to draw conclusions about the population (Easterby-Smith et al. 2008). At the NCS there are clear segments of groups; oil companies, contractors, government, interest-groups, and research institutes. This would yield a sample size of five respondents if one chose just one respondent from each group. In four of the five stakeholder groups I have settled with just one key respondent because of both limited timeframe and the belief that respondents in the same groups of organizations will for the most part have the same viewpoints (normally distributed), and thus would not have contributed with much extra information. The only stakeholder group with two respondents are the authorities, but initially I also wanted to have a second respondent from the petroleum companies so that I had both a big and a small company, but Statoil abstained from participating in the last minute. I sought to interview two respondents in each of the two groups as they are major players that in many cases set the agenda when it comes to innovative developments at the NCS.

	Realist (Yin)	Relativist (Eisenhardt)	Constructionist (Stake)
Design	Prior	Flexible	Emergent
Sample	Up to 30	4–10	1 or more
Analysis	Across	Both	Within case
Theory	Testing	Generation	Action

Figure 9 Key Features of Case Method Informed by Different Ontologies (Source: Easterby-Smith et al. 2008).

One can easily say that the variations in case study design and application are complex and can even in some cases blend into each other, as the figure above summarizes some of the main distinctions in the application of case methods according to three basic research Ontologies (Easterby-Smith et al. 2008). Ontology is about how researchers perceive and interpret, philosophically, the reality they live in or study. Said very short I position myself somewhere between relativist and social constructionism when it comes to social science, but in the bigger research picture it all depends on what is being studied and what the objective is. The latter paradigm assumes that there is a reality which exists independently of the observer, and hence the job of the scientist is merely to identify, albeit with increasing difficulty, this pre-existing reality (Easterby-Smith et al. 2008). In relation to the sampling the figure shows that constructionist and relativist case studies typically settle with one to ten respondents, which makes me confident that I have a good sample size with my six respondents.

In order to find appropriate respondents I have used a non-probability sampling method which contains elements of quota sampling, snowball sampling, and purposive sampling. In non-probability sampling the researcher does not base his or her selection of samples on probability theory, rather efforts are undertaken to create a kind of quasi-random sample to have a clear idea about what larger groups the sample may reflect (Berg, 2009). My sampling strategy has been to divide the organizations into stakeholder groups according to their role and function and choose one (or two) key person in each stakeholder group that could be a representative of that group. This is similar to quota sampling which divides the relevant population up into categories and then select until a sample of a specific size is achieved with each category. Together with stakeholder theory quota sampling was a good tool to divide the actors in stakeholder groups. When developing a purposive sample, researchers use their special knowledge or expertise about some group to select subjects who represent this population (Berg, 2009). Snowball sampling starts with someone who meets the criteria for inclusion in a study, who is then asked to name others who would also be eligible (Easterby-Smith et al. 2008). When I was deciding on eligible respondents, whom I should pick for interviewing from each of the groups, I used both knowledge I had, tips from my supervisor, and advice from my respondents The advice was both regarding suitable companies/agencies and appropriate persons that have relevant information and knowledge about the topic. By acquiring and using this information to find suitable respondents it has elements of both purposive sampling and snowball sampling within it. I wanted to speak to people that were involved in innovative development processes, and preferably people high up in the organizational system or who has worked in the industry for some time. Except from the Statoil drop-out I feel that I have been very lucky with the respondents that I managed to obtain, and I learned a lot from conversation with them. In this study I have interviewed:

- Knut Aaneland director of technology at North Energy
- Bente Nyland director general at the Norwegian petroleum directorate
- Inge Carlsen special advisor at SINTEF
- Gøril Tjetland CCS advisor at Bellona
- Reidar Müller senior advisor at the Ministry of Petroleum and Energy
- Runar Rugtvedt branch manager for oil and gas at the federation of Norwegian Industries

3.3 Data Analysis

The empirical data collected for this thesis is gathered through semi-structured interviews with quasi random picked respondents. The interviews have been recorded and later transcribed into written text. One disadvantage of doing interviews, recording them and then transcribing them into written text, is that this is a process that will require a lot of valuable time. The best solution would be to outsource this task which would save time, but this often entails a cost for the research project. Even though it takes a lot of time to do this job it has also an advantage in that it allows the researcher to get more acquainted with the data which is always a good thing. The number of pages transcribed into text in this study is by no means a big data set, and is thus manageable without the use of any computer program. After transcribing the data into written form I have 34 pages of text from six interviews. All the interviews were organized in the same way and followed the same progression regarding themes, which made it quite easy to sort and analyse the data. The initial 34 pages of data was then washed and cleaned of unnecessary information and put into one 'interview analysis document' and sorted according to the four themes in the interview guide. The statements from the different respondents were put in different colours so that it was easy to distinguish the statements from each respondent in the 'interview analysis document'. The statements from the 'interview analysis document' were then used when writing the thesis, and the statements that had already been used were stricken over by a function in Word. Statement's that were redundant was stricken over twice by the same function in Word. In addition to this effort I also read every interview several times using them for control and double checking making sure that important aspects were not forgotten or misunderstood.

3.4 Validity and Reliability

In research studies it is normal to be concerned about the studies validity and reliability. According to Ruan (2005) research procedures offer great safeguards against error, but error can still make its way into scientific findings. Humans can make mistakes in executing the methods of research – e.g. by contaminating evidence, selecting biased samples, poor interpretation of data, etc. Attention to validity and reliability is necessary to make sure that such errors do not occur. Validity is about the concerns of the study is measuring what it is supposed to be measuring, and consist with issues of both internal and external characters. According to Easterby-Smith et al. (2008) a case study carried out in a relativist fashion typically have similar concerns related to validity as a positivist study. That is whether the instruments and questionnaire items used to measure variables are sufficiently accurate and stable. The contrasting position, which is informed by a constructionist epistemology, is much less concerned with issues of validity in case studies and more concerned with providing a rich picture of life and behaviour in organizations or groups (Easterby-Smith et al. (2008). In this case study validity concerns are relates to the researcher, the interview guide and the respondents and their statements. I have had to ask myself: have I asked the right questions? Can I trust the statements given to me? Have I and the respondent understood the situation and/or topic correctly? And have I chosen appropriate respondents? All of these concerns are related to what is called internal validity. The respondents did not always get the exact same questions, but I feel certain that my questions are relevant and according to what I want to measure. I am confident that I have covered all necessary aspects through my interview questions, which was partly confirmed by some of the respondents who said that I had good questions, and that the interview was interesting to be part of. In the end of each interview I also asked every respondent if they had something to add, just to make sure that I did not overlook anything. I have no reason to doubt any of my respondents and the statements and interpretations they have provided me with, but all the time I have had in the back of my mind that each respondent have their own perspectives based on where they work and which position they hold. One thing that is bad for the validity is that Statoil chose not to participate, and without their 'side of the story' the data set is not as good as it could have been.

External validity is in one part about if the findings in a study can be applied beyond the study that created the findings. The question is; can the results of a study be generalized to other settings? In this study the generalization has not been a major concern because much of the purpose of the study has been to collect data to get a good and rich picture of the topic, and not for generalisation purposes. A qualitative study with a small sample size like this one, typically have low external validity so generalization to other settings is more doubtful in this case. Still other technology driven industries or businesses can find similarities in this study compared to their own development procedures and processes. Another part of external validity is about the robustness (reliability) of the study; that is if the study can be replicated over and over again with the same results every time. I firmly believe that the results from this thesis can be replicated in other studies, with both different researcher and respondents. The only reservation is that it is carried out in the same manner, with same design and execution. The interview situation may be difficult to copy exactly, but my impression after the interviews is that the topic is well known, the information flows in the open, hence other researchers would very likely end up with roughly the same' data set after the interview. All else being equal the only issue that could reduce the reliability assessment slightly is that different researchers might interpret the data differently and thus come up with a different conclusion. Because of my sampling strategy I am also very confident that my sample has provided me with very rich and good information that can be generalized to that of the population.

My research design, choice of respondents and their positions and the fact that this topic is well known and not very sensitive gives me confidence to claim that this thesis have strong validity and reliability, and thus without mistakes or biases of any kind.

3.5 Ethical considerations

Bell and Bryman (2007) have conducted a content analysis of the ethical principles of nine professional associations in social science. They identified ten principles of ethical practice where the first seven are about protecting the interests of the research subjects or informants, while the last three concerned ensuring accuracy and lack of bias in research results. When doing research and collecting data from respondents there is always the possibility that the respondents put their name and reputation and even their job at stake when they give their opinions that is later printed and up for scrutiny. The researcher needs to 'protect' his or her respondents with tools like anonymity, shielding sensitive information from the public, not to interpret their statements etc. In order to protect the informants I have made sure that the respondents are fully aware of the purpose of the thesis and what contribution that I expect from them. This is to avoid misleading the respondents of the nature of the research and to make sure that I got as precise data as possible. I wanted to record the interviews to make sure that I understood accurately the information, the context in which it was given, that I didn't neglect any information given, and to be sure that I reproduce their opinions correctly in the study. Recording the interviews was also preferred because of my lack of being able to write notes. Every respondent were asked in advance if they had any reservations against this method of data collection, which none of my respondents had. In some cases the respondents may feel uneasy with the use of a recorder, most likely because if they wished to they would have difficulties going back on statements that can be played back as 'evidence' later, and it is more problematic to claim wrong quotation. There was no need for anonymity of respondents in this study as I have interviewed respondents that have official positions, and their answers reflect this position. No respondents have uttered the need for anonymity, and thus they stand by what they have said by name. In order to ensure lack of bias every respondents were sent the transcribed interview so that they could read through it to make corrections or adjustments to their statements if they pleased. No major changes were made by the respondents after the interviews.

4. Empirical Data – Technology Development at NCS

4.1 Stakeholders of the Petroleum Industry in Norway

To be part of the resource extraction at the NCS there is an embedded need to be innovative, and technology development is seen as a competitive advantage to be in front, much because of the harsh conditions but also because of demands from the authorities. The stakeholders of the petroleum industry in Norway are defined as actors that in some respect have an interest in the industry. Stakeholders of the petroleum industry and stakeholders of the process of technology development are considered to be the same stakeholders since technology development is a crucial part of the petroleum industry. Technology development at the NCS is a system that is driven by governmental efforts, private and state owned companies, contractors (service companies), research institutes, universities, and the community. The technology development at the NCS is driven forward by collective efforts from these multiple stakeholders'. In this study I have via secondary data mapped and divided the stakeholder into five groupings according to their role and function which can be seen in figure 10 below. By replacing a specific company in the centre with technology development and placing the stakeholders around the topic of the thesis it gave me a starting point for my further research.

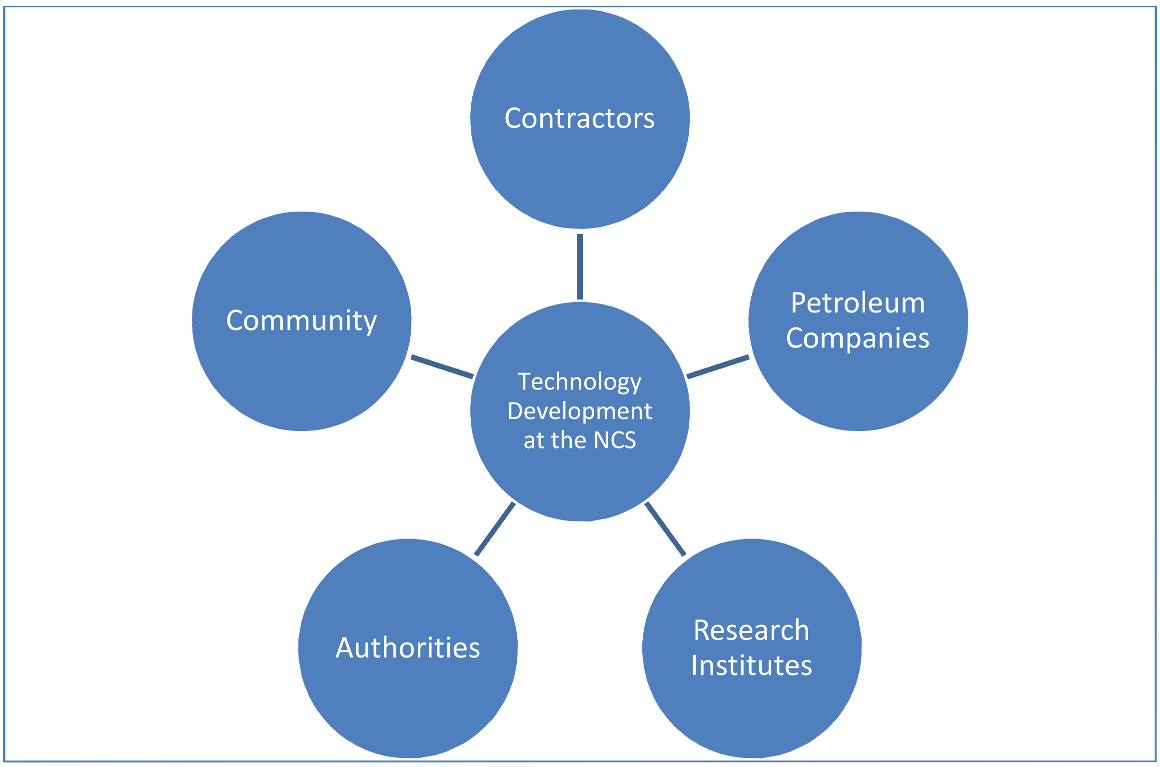


Figure 10 Technology Development at the NCS and Stakeholders by role and function

All groups in the figure are stakeholders that have an interest in technology development in some respect; either it is the authorities with its funding and regulations, the research institutes that are making some research report, or the community that voice their opinions. The main contributors to technology development are those who invest the most into research & development, namely petroleum companies and contractors. The authorities' also plays an essential part, which will be described shortly. All stakeholders play a significant, if not equal, role even though the efforts, motives, and budgets may vary across and within the groups.

4.2 The Authorities and Their Organization of the Petroleum Industry

After many discoveries, especially after the Ekofisk field began production in 1971, it became clear that there were great values at the NCS and a need for a good way of organizing the business. The government wanted a strong national ownership and strong governance. The challenge with structuring the petroleum sector was to get a system in place that would help the management of petroleum resources – a system that would maximize value for the whole of the Norwegian people and the Norwegian community (Faktahefte 2010, p. 18). It was also important for the oil companies to be able to make rational decisions on their investments, and thus it was a prerequisite that the framework was predictable and transparent. Organization of activities, roles and responsibilities ensures that important social considerations are taken into account, and that value creations are made in the name of the commonwealth. At the same time the views of the environment, health, working and safety environment plays an important role. In 1972 the Parliament adopted a tripartite approach with regard to how the state should deal with its involvement in the petroleum sector. Politics, Government and business were split in the following way (the Norwegian Petroleum Museums yearbook, 2008, p. 46):

1. The political responsibility for matters related to petroleum was put in its own section within the ministry of industry. In 1978 the Parliament established a separate oil- and energy ministry.
2. The NPD was established to be responsible for resource management and safety regulations. That is, the NPD collect and process geological and geophysical material from the NCS, and controlling that the petroleum industry is in compliance with the law and the safety and working regulations at the NCS.
3. State oil company Statoil AS was established to safeguard the state's business interests.

4.2.1 The Parliament and Government

The organization of the petroleum industry today is not very different from the initial, except that it may now be seen more as a quadripartite and not a tripartite as originally. Over the years there have been small changes back and forth but in 2001 the authorities' structuring of the petroleum industry changed more significantly with the establishment of new state owned companies. In 2004 the petroleum safety authority Norway (PSA) was established and today the NPD shares their old duties, and new ones, with the PSA. Presently the authorities have organized their tasks related to the petroleum industry as seen in the figure below.

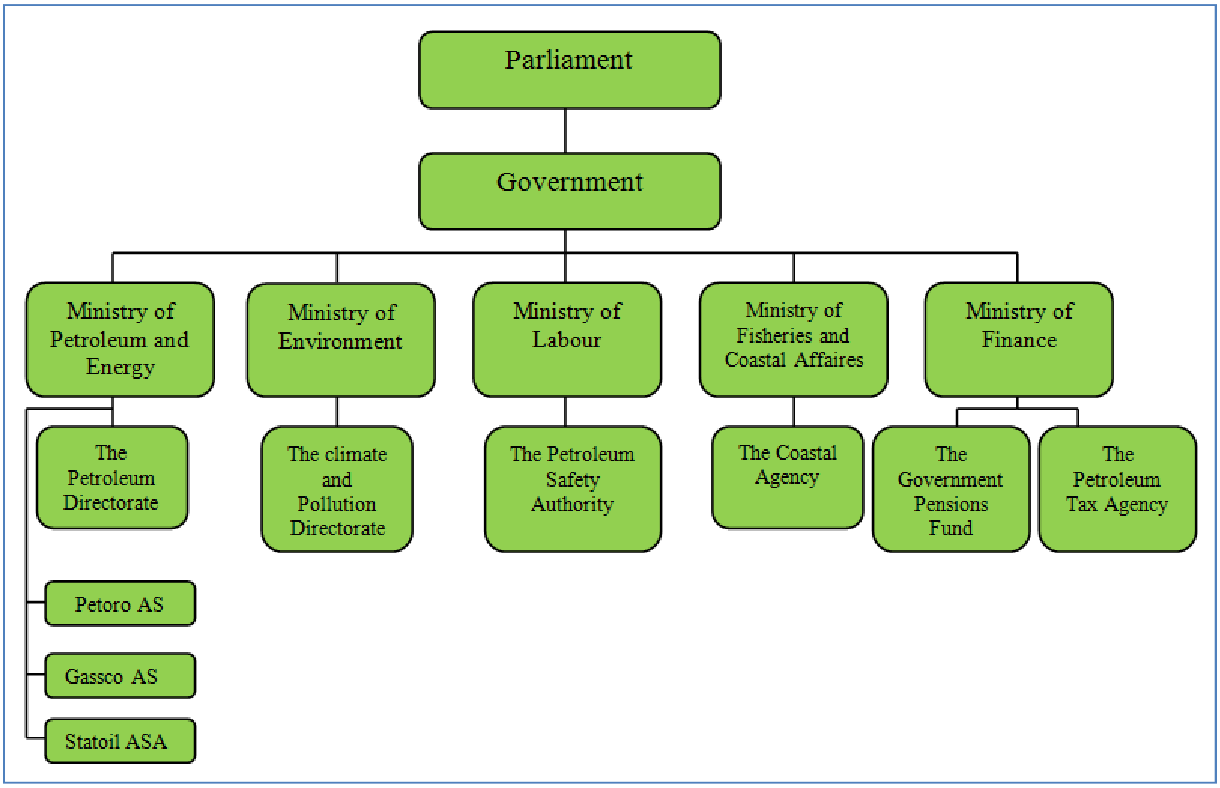


Figure 11 Governmental Organization of the Petroleum Industry (Source: Faktahefte 2012)

At the top is the parliament, which sets the framework for the petroleum sector in Norway with laws and regulations and they also controls the government and the public administration. Major development issues and principal matters are discussed there. Some of the laws and regulations that function as framework and facilitation for the industry and innovative development are the income tax, the accounting agreement, and the tax agreement for innovation. *The Norwegian income tax system* for petroleum operations is based on ordinary company taxations of 28 percent. Since the petroleum industry is especially profitable they are subject to an additional tax of 50 percent. The total taxation level on petroleum operations is hence 78 percent in Norway. This is slightly higher than most other countries with petroleum resources, which have taxation rates in the range of 30-60 percent on petroleum activities (Report on International Petroleum taxation, 2008, p. 9). The Norwegian taxation system gives incentive for petroleum development projects in that it provides good conditions for depreciation of investments over time and deduction of all relevant costs, including costs related to exploration, research & development, financing, operations and removal (Faktahefte 2012, p.16). With these favorable conditions for depreciation and deduction the actual taxable amount can be much lower as long as there is continued investment in petroleum projects and research & development efforts in Norway. In this way much of the risks involved in petroleum projects are taken by the authorities. Deduction of costs related to exploration also gives petroleum companies incentives to try new methods/developments etc. to locate petroleum resources, and if they do not find anything or the methods fail they will receive a reimbursement of most of their costs. Through *the accounting agreement* the operator companies can receive refunds of costs related to research and development. In order to get this refund the companies have to document that they have used the investments as the license requires. The investment shall be used for research and development with relevance for the NCS, and do not have to have any specific relevance for the license they operate. The financial agreement contributes to significant amounts being channeled from the industry into technology development and projects of importance to increased recovery (report from the Extraction Committee, 2010, p. 37). Another scheme is *the tax agreement for innovation* (SkatteFUNN) which is an agreement that was established in 2002 and is Norway's largest effort on research and development directed at small and medium sized businesses. The system is administrated by the Research Council of Norway (RCN) in collaboration with the organizations Innovation Norway and the Tax Administration. SkatteFUNN is an agreement that gives, small and medium sized businesses operating in Norway, a deduction in taxes of 20 and 18 percent respectively of costs in approved research & development projects. The criterion for approved projects are that they must be aimed at obtaining new knowledge, or new skill which may lead to new or improved goods, services or production processes (www.forskningradet.no)[6].

The government has the executive power of petroleum policies and are accountable to the parliament for its policy. The government is responsible for handling day to day business and make sure strategies and plans are followed in all efforts related to petroleum. In order to

[6]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1222340152207&pagename=skattefunn%2FHovedsidemal

exercise the policies the government receive assistance of governmentally established ministries and their subordinate units. The MPE is naturally the focal ministry when it comes to petroleum matters, but all of the ministries in the organizational chart presented previously have duties related to the Norwegian petroleum industry:

- The Ministry of Labour is responsible for Health, Safety and Environment (HSE)
- The Ministry of Finance is responsibility for the income to the state
- The Ministry of Fisheries and Coastal Affairs are responsible for oil spill prevention
- The Ministry of Environment naturally have responsibility for environmental issues

In the following only the authority agencies that have closest ties to the petroleum industry and innovative developments are brought into the light.

4.2.2 The Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy (MPE) states that; "The research & development in the petroleum and energy sector is a prioritized area for the government" (www.regjeringen.no/en/dep/oed)[7]. The petroleum sector is a major source of revenue for Norway, and future value creation in the petroleum sector depends on how effectively they manage to exploit the remaining resources at the NCS. To accomplish this in a best possible way they have a need and interest for continued technology development. The MPE's primary mission is to facilitate a coordinated and comprehensive energy policy, and for this they have established four departments where oil and gas is one of them. Here they work to facilitate and organize the petroleum sector requiring them to have dialogs with politicians, other ministries, supporting organizations, and miscellaneous agencies. Further the MPE has the responsibility for the resource management and the sector as a whole. To be able to manage this daunting responsibility creation of governmentally owned companies has been vital. Subordinate to the MPE some state owned companies have been established to help manage the industry and Statoil AS is one example of a wholly state owned company that was established in 1972 to safeguard the state's business interests related to the petroleum sector. But as the income from the petroleum business grew it became clear that there was a need to separate this Statoil As cash-flow into a company part and a state part. Today the state only have approximately 67 percent ownership in Statoil ASA the rest is in private hands. When

[7] http://www.regjeringen.no/en/dep/oed/Subject/energy-and-petroleum-research.html?id=86983

Statoil ASA was listed on the stock exchange in 2001, PETORO AS was established as a fully state owned company managing the states direct economic assets (SDEA). The SDEA consists of the authority's portfolio of assets at the NCS, being licenses, pipelines and onshore facilities where the state has direct holdings. Gassco AS is another fully state-owned company established in 2001 to be the operator of the pipeline network and the major onshore facilities for gas. These state owned companies (only Statoil ASA not fully state owned) are all subordinate to the MPE and is established to help organize and manage the petroleum industry and its development.

4.2.2.1 Strategizing for the Future

The need for a coordinated national effort in petroleum related research & development led the MPE to formation of the board of Oil & Gas in the 21^{st}. Century (OG21) in 2001. This is a work group established to help the petroleum industry to formulate a national technology strategy for added value and competitive advantage in the petroleum industry, necessary to mitigate the challenges the petroleum industry is facing in the 21^{st}. Century. The duty of the board of OG21 is to develop a national technology strategy for the Norwegian petroleum industry and serve as advisor for the authorities and businesses. The purpose with OG21 is to ensure an effective and environmental added value of the Norwegian oil and gas resources through a coordinated engagement, in the petroleum cluster, in education, research, development, demonstration and commercialization (www.og21.org)[8].

In response to its duties OG21 released a strategy document in 2001 with a focus on strategic areas of technology that are appropriate to increase the reserves and maximize production at the NCS, and to achieve a cleaner and more energy efficient production while at the same time maximizing added value through export of technology. The strategy has been revised a couple of times, and last time it was revised was in June 2010. The main goal of the OG21 strategy document is to create an environment where all the actors participate and pull together towards common goals related to the research & development activities. In short: to unify the research & development activities towards the common challenges at the NCS. The OG21-strategy is also designed to function as guidelines for public spending and as a foundation for technology strategies within the oil and gas industry. In the strategy document the worst case scenario is mentioned as a possible outcome if the government doesn't take

[8] http://www.og21.org/servlet/Satellite?c=Page&cid=1253962785364&pagename=og21%2FHovedsidemal

their role seriously; "Government involvement is important to stimulate research and development of high expertise that can be applied in Norway. Without incentives the industry can come to move research activities abroad. The increasing competition from abroad makes it necessary for the authorities to undertake a long-term commitment and support of the supplier industry in Norway (OG21 Strategy Document, 2001, p. 15).

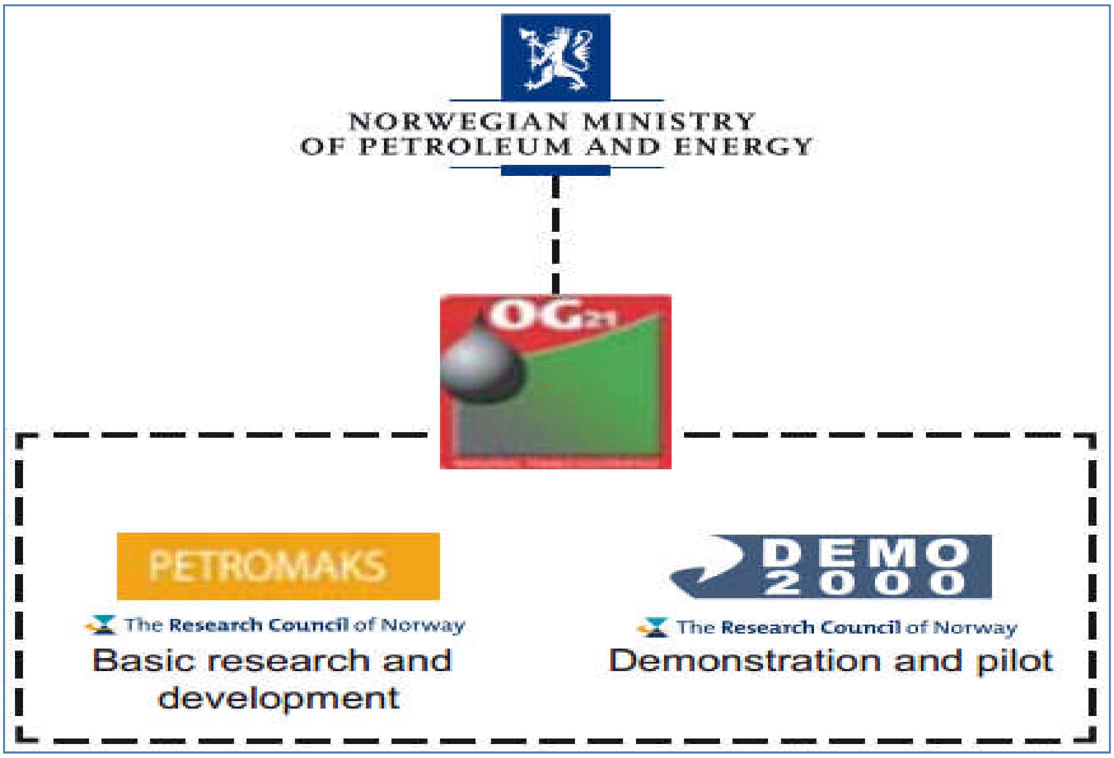


Figure 12 Ministry of Petroleum and Energy's main involvement in petroleum research (Source: Faktahefte 2012)

The main technology target areas of the OG21 strategy are:

1. Value creation through production and reserve replacement; Increased reserves by five billion barrels of oil by 2015
2. Energy efficiency and cleaner production; Maintain Norway's position as the oil and gas province with the highest efficiency, lowest level of emissions to air and the lowest levels of harmful discharges per produced unit
3. Value creation through increased export of technology, to continue the current growth path with annual sales of oil and gas technology of 120 billion by 2012
4. Value creation through employment and skills development; Maintain and further develop Norway's position as a leading and competitive cluster in the oil and gas technology

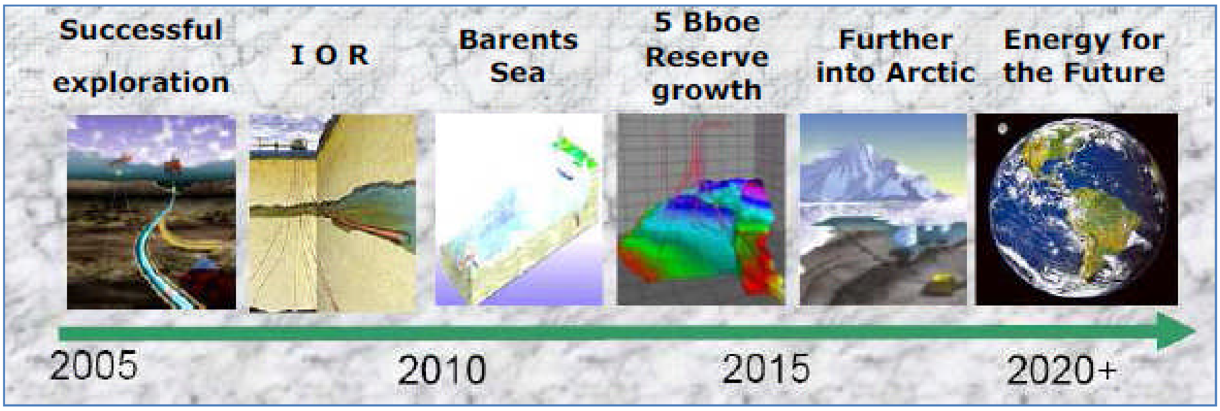


Figure 13 OG21's Technology Roadmap for Value Creation at the NCS (Source: OG21 Strategy Document)

To reach the technology targets four task forces have been put together; Energy efficient and environmentally sustainable technologies, Exploration and enhanced recovery, Cost effective drilling and intervention, Future technology for the production, processing and transportation. The OG21s' board estimates that to implement the strategy the public spending to research and development activities towards the petroleum industry needs to be in the range of 600-800 million NOK (OG21 Strategy Document, 2001, p. 3). The major barriers that have been solved and need to be overcome in the future to meet goals and targets set are illustrated in figure 13 above - challenges and expected technology progress in the future.

4.2.2.2 Authorities Funding of Petroleum Research & Development

Another role of the MPE in relation to technology development is that they are responsible for allocating funds for research & development, and to distribute them in a cost effective way to get as much value as possible from the input. As already mentioned the funds from the Norwegian authorities to petroleum research are channelled through the RCN. According to Bente Nyland (2011) the decision of how much funding, to what purpose, and to who is a process where the MPE, the government and the parliament are the only governmental agencies involved. The MPE each year have a budget conference where they prepare research proposals for new priorities and how much funding that is needed. Reidar Müller (2011) states that; "when the MPE follow-up the RCN we can make constraints on priorities, but at the same time we often ask the RCN for advice and them to us, it's a two-way dialog". In this it can be understood that the MPE do not set allocations without consulting other relevant governmental agencies first. Then allocation proposals are sent to the government that either accepts or rejects the proposals (Reidar Müller, 2011). The authorities funding of petroleum research have been a relative fixed amount of approximately 400 million NOK in recent years, and if some additional proposals are accepted or rejected this will either increase or decrease this fixed amount. The governmental financing is mainly prioritised towards education, basic research, long-term technology and stimulation of pilot testing of technology.

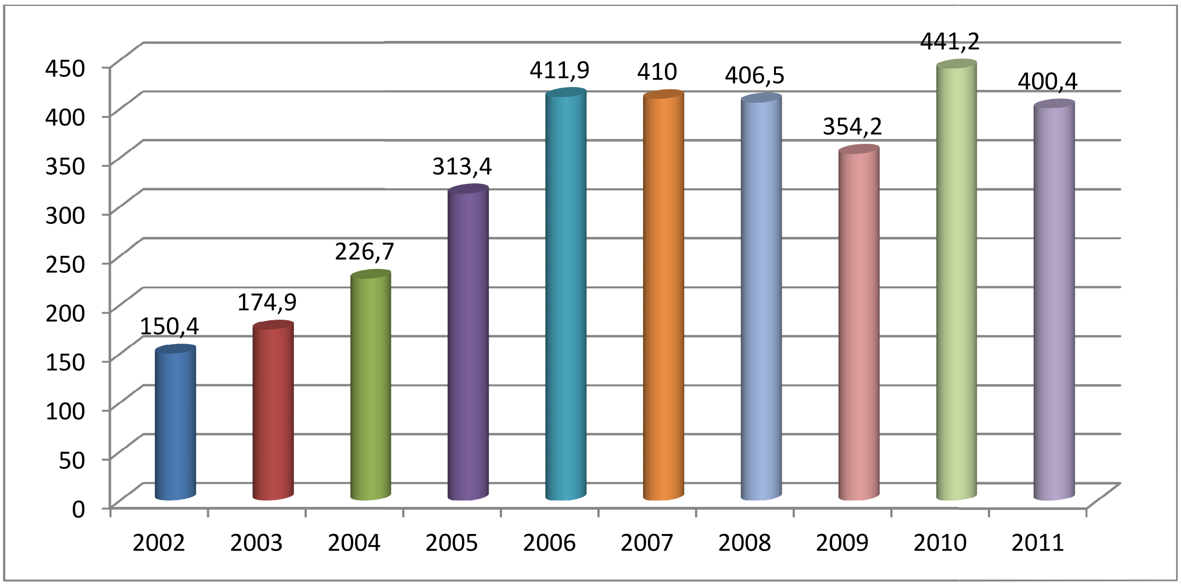


Figure 14 Governmental Grants to Petroleum Research (Source: RCN, appendix 2)

From the figure above we can see that the governmental funding of research has increased since 2002 with a top in 2006. 2010 is the actual year that received the most governmental funding, but this was because of the Norwegian stimulus package which increased the funding with 50 million NOK that year. The stimulus package was a response to the recession in 2008/2009; otherwise the total sum in 2010 would have been just 390 million NOK. The OG21's board has, as mentioned earlier, estimated that in order to implement the strategy and get as much value out of the NCS as possible the governmental grants to petroleum research and development needs to be around 600-800 million NOK each year. This constitutes quite a gap between the amount stated in the OG21 strategy and the authority's spending of around 200-400 million NOK. The perceived lack of will to increase the governmental funding gives some of the actors of the innovative process a feeling of resignation towards the present government, and they are hoping for better conditions after the next election in 2013. Several of the interviewees expressed this frustration by suggesting that the governmental funding are peanuts compared to what is really needed, and especially toward piloting (Runar Rugtvedt, 2011). Knut Aaneland (2011) feels that the authorities can be some narrow minded sometimes and should have a wider perspective because the Norwegian society receives 90 percent of the income from oil and gas, thus there is little risk in increase the amount to petroleum research with one billion or more. This view is supported by several others who mention different reasons why more funding is needed; the Extraction-Committee (also called the Åm-Committee) released a report in September 2010 stating that the need for increased funding to petroleum research is needed because of maturing fields. They mention that time is of essence if the remaining oil in mature fields is to be exploited to its fullest before the fields are closed down for good. This is also true for small petroleum reserves that have not been developed yet, and which have to be developed before existing infrastructure is brought to a halt because nearby maturing fields are shutting down. They also express that the reserve growth is dwindling so it is important to increase the funding to find and develop both new discoveries and development fields. In an article in www.politikkavisen.no[9] the Norwegian confederation of trade unions, the Federation of Norwegian Industries (FNI), the Ship-owners Association, and the Oil Industry Association together voice their concerns with the proposed funding for 2011 in the light of reduced possibilities for self-funding through big fields that covers the costs. This group has realized that in times where no big fields that can cover huge research and development costs are found, authority stimulation is important. This is a major concern to technology development since big fields sustain technology development, while small discoveries do not have the ability to finance technology development (Knut Aaneland, 2011). The finding of the Norvarg field (190 km offshore) is one example of this; the field is located further out into the sea than the Snow White field (140 km offshore) and today it is close to impossible to transport petroleum in pipelines over such distances since the technology and infrastructure that is needed is not yet developed. The Snow White field is in the forefront of what can be achieve when it comes to petroleum transport in pipeline over distances, and the Norvarg finding is both further offshore and too small to single-handedly finance required technology and infrastructure (Bente Nyland, 2011). The MPE has reservations to increase the amount to the level expressed in the OG21 strategy. They feel that the amount 600-800 million is a desired and almost a wishful amount the industry feel they need, and a sum that is very difficult to manage politically. The government each year have to decide how much money they can grant to the different assignments in the budget, which is an exercise in budget settlement where a relative fixed amount has to cover a lot of 'good causes'. It is easy to imagine that in situations where you have to choose between better elder care and better research the choice would be quite easy in the budget settlement process; both because of moral considerations and because you can grant financing to something that give immediate results. But in critical times to certain industry one can expect that good causes and social

[9] http://www.politikkavisen.no/www__Dolf__Dno/_Konkraft-Petroleumsforskningen-m-styrkes-betydelig.php

benefits may have to wait till next year because business opportunities are lost if investment are not done right away. Another concern of the MPE according to Reidar Müller (2011) is that they are not sure if the research environment is able to absorb such a huge lift in the funding, and they ask themselves; Are there enough researchers? Is there enough good projects? Reidar Müller (2011) also mention that it can be a problem with swift increases in governmental funding, that it will take time for research institutes and other research actors like the universities to adapt and increase their capacity to meet the increased funding. The ministry acknowledge that the governmental funding is very important, but only a small part of the total amount spent each year on research and development aimed at the petroleum industry, but at the same time they remind that the governmental funding triggers huge investments from the industry. In recent years Norway has had a period with only small discoveries which have influenced the contractors and the petroleum companies' ability to invest large amounts in research & development. The authorities should maybe have started increasing their funding some years back. The recent finding of the big Statoil operated Johan Sverdrup field in the North Sea is a quite pleasant 'surprise' to the industry in a time where one had written off the North Sea as matured, and in a time where recent findings have been few and small. This gives grounds for reassessing the NCS and the assessment of the North Sea. So far it can only be seen as a bonus that they have found petroleum in an area believed to be matured or full of small pockets of petroleum. Norway can only wish that this was not the last big field and hope for more big 'surprises' on Norwegian territory in the future as new exploration areas are being opened.

4.2.2.3 Different Perspectives - Authorities and Petroleum Companies

The operators at the NCS are naturally mostly concerned with investment in efforts that are relevant for fields they are operating and difficulties/needs they face there. According Reidar Müller (2011) "…this is an important challenge for the MPE, to find the areas where the companies do the job themselves, and the areas where the government can play an important role, and we are often concerned with the areas of long term research and to get more out of each field (IOR/EOR)". Müller (2011) gives one example; "If an oil company is considering testing some chemicals that is believed to increase the oil recovery in ... let's say the Brage field, and they find out that it would yield a negative net present value, they then wouldn't go ahead with the project. But we the authorities have a different perspective, and are more concerned with the potential in the project. If the technology seems promising and has potential use in other fields, the authorities will give a go ahead for the project even if it has a negative net present value". Thus one can say that the oil companies do not always implement projects that have economic or technical risks associated with them. In cases where the government find it to be socioeconomic reasonable to develop or implement technology, their funding can help start projects that the industry wouldn't have done otherwise. Müller (2011) further states that; "this is the role of the governmental funding, to spur socioeconomic research that is not perceived as profitable for the petroleum companies".

4.2.3 The Norwegian Petroleum Directorate

The NPD is a governmental specialist directorate and administrative body established in 1972 subordinate to the MPE. The paramount objective of the NPD is to contribute to creating the greatest possible values for society from the oil and gas activities by means of prudent resource management based on safety, emergency preparedness and safeguarding of the external environment (www.npd.no)[10]. The NPD also set frameworks by; stipulating regulations, follow-up of regulations, and making decisions in the area they have authority. At a conference in Bergen the twenty-third of October 2002, the former director general of NPD Gunnar Berge, stated that;"the regulations shall not be experienced as a straitjacket for the industry, but leave room for the innovation and creativity" (www.ptil.no)[11]. He follows up this statement with "I believe that the regulation of today provides the right framework conditions". Together with the MPE, the NPD is also responsible for the security of supplies. The NPD is not directly involved in the technology development process as they do not contribute with funds, research or development, but they work as a driving force for research & development, HSE matters, and implementation of technical solutions that can mitigate challenges related to their authority area. According to Bente Nyland (2011) this is according to their role not to be the owner of the process since their perspective is that; it is the industry in collaboration with the research and educational institutes that are the ones that should come up with solutions. The NPD can only point to certain issues and state that they think more can be done here and there". One example of where they have done this can be viewed in an article at www.aftenbladet.no[12] where Bente Nyland goes out against the petroleum companies and request bigger efforts in form of funding and long term planning in relation to

[10] http://www.npd.no/no/Om-OD/
[11] http://www.ptil.no/nyheter/regelverket-ingen-tvangstroeye-article763-24.html
[12] http://www.aftenbladet.no/energi/olje/Oljedirektoeren-refser-selskapene-1888403.html

IOR and EOR. The NPD challenges the industry in relation to certain issues they find important, and they go into direct dialog with the industry to find out what they are thinking, doing and are planning to do in the future in relation to these issues. In addition to this the NPD is part of different bodies with different functions related to petroleum research & development. With several small players and small discoveries at the NCS, coordinating of testing of new technology across the licenses will be even more important than before. Hence the NPD established a forum called FORCE in 1995 with a mission to stimulate industrial cooperation (www.force.org)[13] between petroleum companies and the authorities of Norway. The focus in this cooperative effort, except the obvious to increase cooperation, is to improved oil and gas recovery and improved exploration. The body currently consists of thirty five oil and gas companies that have agreed to look for opportunities to share the costs and results related to field pilots (white paper nr.28, 2010/2011, p. 64). The authorities will through FORCE continue to lift forward additional pilots, and together with key players at the NCS work for increased efforts related to testing of new technology. A cooperation contract is developed to make it easier to cooperate between licences under the Force organization (Bente Nyland, 2011).

4.2.4 The Petroleum Safety Authority Norway

Subordinate to the Ministry of Labour, the PSA has the regulatory responsibility for safety emergency preparedness, and the working environment in the petroleum sector. This responsibility was taken over from the NPD when PSA was created in 2004. The agency's regulatory authority was extended to cover safety emergency preparedness and the working environment in petroleum related plants and associated pipeline systems (www.ptil.no)[14]. The goal is that commitment to safety shall pay off. The master idea is that companies through a thorough and professional approach to HSE will avoid costs associated with accidents and adverse events such as repairs, production shutdowns, possibly higher insurance premiums, lost rates of revenue, loss of intellectual capital and the like. In addition to reducing costs, a commitment to HSE also directs revenues by contributing to increased reliability, robustness against undesirable events, greater flexibility, and increased efficiency by making the business less vulnerable. The PSA's efforts are illustrated by the statement of Gøril Tjetland (2011) stating that "the PSA is quite eager to push for adoption when it comes to implementation of

[13] http://www.force.org/About-FORCE/
[14] http://www.ptil.no/role-and-area-of-responsibility/category165.html

technology related to HSE". As they have a regulatory responsibility they also supervise that the laws and regulations set by the authorities related to the PSA's duties are followed. As with the NPD, the PSA also works as a driving force for research and development efforts that can improve the performance while they at the same time try to challenge the industry to do more within the PSA's authority area.

4.2.5 The Research Council of Norway

The RCN is a governmentally established council and strategic organ that is responsible for advocacy of Norway's research domestic and abroad by; manage research funding, distribute scholarships and give the government advice on research policy issues. In the RCN's document of statutes their purpose is described: "The RCN shall serve as a national strategic and executive body for research. The RCN is responsible for increasing the general knowledge base, and for helping to meet society's research needs by promoting basic and applied research as well as innovation. The RCN is promoting international research cooperation and serves as an advisory body to the authorities in matters concerning research policies" (RCN Statutes, 2001)[15]. The RCN has a formidable area to cover and comprises of four research divisions where one is the division for energy, resources, and the environment.

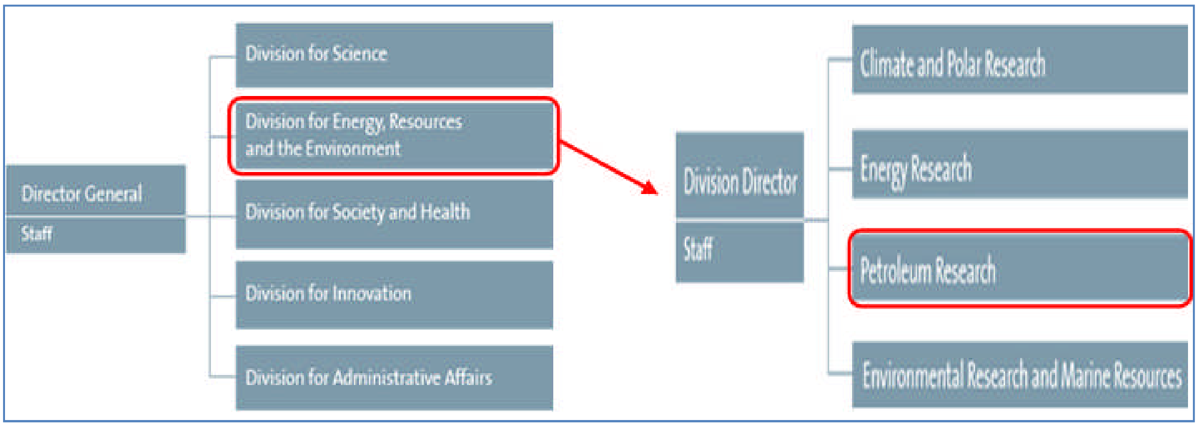


Figure 15 Organizational Chart of the RCN (Source: www.forskningsradet.no)[16]

The division is responsible for research and innovation targeting national and global challenges associated with energy, petroleum, climate, polar, environmental and marine

[15] http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3DRCNStatutes2011.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274468227525&ssbinary=true
[16] http://www.forskningsradet.no/en/Organisation/1138785841802

resources sectors. With so many target areas it has been necessary to divide the division into departments with their own specialized area; where one department has the sole responsibility for the petroleum sector. The department of petroleum is responsible for research, innovation and demonstration efforts in relation to petroleum. They work to achieve advances in expertise and technology that can improve the exploitation of Norwegian petroleum resources and enhance the competence of Norwegian players within the research community and petroleum industry alike. The petroleum department at the RCN has an extensive cooperation with; other ministries, the industry, and research groups nationally and internationally. Strategic, advisory and financing assignments related to the field are anchored here, and there are connections to the national strategic body OG21. The profile of the strategic petroleum research funded by the RCN is thus reflecting the precedence of the OG21 strategy, ensuring a coordinated effort between universities, research institutes and the petroleum industry.

4.2.5.1 Petroleum Programs and Other Petroleum Research Efforts

The RCN's role in technology development is for the most part related to funding, research, and administration of the programs they offer. The RCN channels most of their received petroleum research funding into few but big programs, and lesser amounts are given to a handful smaller projects and programs. The governmental funding is deposited to each project or program, and the industry can apply for the venture most relevant to them and receive the funding if they meet the program requirements. To be part of one of RCN's research & development programs companies have to apply for participation. The government had the long term goals and strategies in the back of their mind when they created these programs, so in order to get accepted in one of the programs one has to comply with the regulations and constraints present in the projects. The programs are aimed at issues that the government find important and that are anchored in the OG21 strategy, and where the industry would not necessarily have initiated on its own. Some programs calls for multiple participants amongst the actors of the industry, and it is the authority's wish that it could lead to more openness and cooperation within the industry. Below a few programs related to petroleum research are introduced.

PETROMAKS is the biggest petroleum program and was established in 2004 and works as an umbrella for most of the petroleum oriented research supported by RCN. Further the program is a key instrument to implement the national technology strategy - OG21. PETROMAKS covers basic research, applied research and technological development. Target groups are universities, colleges, institutes and businesses. The authorities have special responsibilities to stimulate to increased competence building in the shape of education, recruiting and basic research. The strategic basic research projects are mainly conducted at the universities. The educational institutes receive governmental funding for research through PETROMAKS. The program supports long-term capacity building, education and technological development, which are necessary elements in order to exploit the resources at the NCS optimally, while simultaneously developing competitiveness of businesses. PETROMAKS thematic areas for research and innovations are:

- Environmental technology for the future
- Exploration and reservoir characterization
- Enhanced recovery
- Cost effective drilling and intervention
- Integrated operations and real time reservoir management
- Subsea processing and transportation
- Deepwater, subsea and arctic production
- Gas technology
- Health, Safety and Environment

The program also supports the strengthening of alliances, creation of networks and facilitation of various types of cooperation with the world's leading scientific and technological institutions (www.forskningsradet.no)[17]. In the first five years of the program the focus has mainly been on exploration, realization of reserves and increased recovery rates. New signals from the authorities suggest more efforts towards energy efficiency and cleaner production, while at the same time keeping focus on better recovery rates (www.forskningsradet.no)[18]. In 2010 the program received about 231 million NOK in governmental financing, and 226 million NOK is allocated for 2011. According to Knut Aaneland (2011); "The program is for the most part user-driven and an arena for the contractors. In PETROMAKS projects it is

[17]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1226993690951&pagename=petromaks%2FHovedsidemal
[18]http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3D20101202PETROMAKSProgramplan.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274465306874&ssbinary=true

normally an oil company, a contractor and a research institute who are working together, but the applications normally are fronted by research institutes and contractors”.

DEMO2000 was established in 1999 and is an initiative supported by the MPE in order to ensure long-term competitiveness of the petroleum industry and continued profitable development of the petroleum resources of the NCS. The program also aims to develop innovative Norwegian industrial products, systems and processes for the global offshore market (www.forskningradet.no)[19]. The program has three main goals:

1. New field development on the NCS through new, cost-effective technologies and implementation models
2. Increased security for completion within budget and schedule
3. New Norwegian industrial products for sale in a global market

Through demonstrations (pilot projects), new and cost-effective technologies can be qualified for use, and thus creating new products, new jobs, and new projects. Pilot projects involve close collaboration between suppliers, research institutions and oil companies, which in itself will develop a future-oriented, market-oriented expertise network (www.forskningradet.no)[20]. Most of the demonstration or piloting under DEMO2000 is done physically at the offshore fields or at onshore processing plants. In a cooperative effort like this participants share the costs involved which reduces the risks involved for all participants; and help qualify technology that would otherwise have been too risky for the participants to carry out alone. Initially the program was set to have around 100 million NOK each year at disposal to demonstration related projects (white paper nr. 2, 1998-1999), but no government have managed to achieve this. DEMO2000 have in fact been favoured with much less than initially set, only in 2006 (70 million NOK) and in 2010 (98 million NOK) has the program been close to this amount. The explanation of the ‘high’ amount in 2010 was due to fact that the program was favoured with an extra 50 million NOK from the governmental stimulus package related to the recession in 2008/2009. DEMO2000 is an important program but has only 46.7 million NOK to spend in 2011 on subsidising the industry for piloting projects. “The authorities funding of DEMO2000 is small change when you think of what is happening at Ormen Lange

---

[19]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296565509&pagename=demo2000%2FHovedsidemal
[20]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296565475&pagename=demo2000%2FHovedsidemal

at the moment, where they have a pilot running to test gas compression technology, where the investment is about 4.5 billion NOK" (Reidar Müller, 2011). Still the establishment of the DEMO2000 project give incentives for technology development, and according to their annual report (2008)[21] Demo2000 has between 1999 and 2008 handed out 2.5 billion NOK, which has released amounts four times that amount in form of investment from the industry. According to Runar Rugtvedt (2011) the typical distribution of costs in Demo2000 is that the government covers about 25 percent, contractors cover 25 percent, and the oil companies cover the remaining 50 percent". In June 2005 NIFU STEP was commissioned by the MPE to evaluate the DEMO 2000 program; which they found to be a success as it had reached its main objective. Hence the authorities decided to continue the program (NIFU STEP, rapport 7, 2005).

PETROSAM is a program that develops expertise on social issues as a basis for strategy and policy of the Norwegian government and business in the petroleum sector. Established in 2007 the program runs till 2012 and have a yearly budget of approximately 10 million NOK finances by the MPE and Statoil ASA. The primary objective of the PETROSAM program is to increase insight into petroleum activity in a societal context in order to provide the Norwegian petroleum authorities and petroleum industry with the best possible basis on which to devise policies and strategies. The program has two secondary objectives, one structural and one scientific. The structural objective of the program is to encourage the development of a stable, permanent and highly skilled Norwegian research environment in the field of social science-related petroleum research. The ambition is to develop strong communities that can compete internationally within the themes the program covers. The scientific objective of the programme is to generate knowledge in the following priority research areas (www.forskningsradet.no)[22]:

- Management of the Norwegian petroleum resources
- International development trends and the value of the Norwegian petroleum resources
- Developments in key petroleum provinces

[21]http://www.forskningsradet.no/servlet/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-Disposition%3A&blobheadervalue1=+attachment%3B+filename%3D%C3%85rsrapportforDEMO20002008.pdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1274461459047&ssbinary=true

[22]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296578138&pagename=petrosam%2FHovedsidemal

The programs shown above are the ones that receive the most governmental funding, but there are also minor programs and efforts related to petroleum research & development that also contribute to the process of innovative development, though with lesser governmental funding. Below a few programs and ventures related to innovation and technology development are mentioned:

- GASSMAKS seeks to increase the society's value creation from the gas industry by improving knowledge and economic development that lead to international competitiveness (www.forskningsradet.no)[23].
- The Ocean and the Coast program's main objective are to promote innovative research of high international quality of the marine environment. The PROOF research program, which is scheduled from 2006 till 2015, is part of the "Ocean and the Coast" program and examines the long-term effect of discharges from the petroleum sector.
- FORNY/FORNY2020, or 'Renew' directly translated, is a program which seeks to increase the value creation in Norway through commercialization of research results from governmentally funded research projects. The program is cooperation between the RCN and Innovation Norway. FORNY2020 is running from beginning of 2011 and is overlapping the previous project that has been in effect since 1995 (www.forskningsradet.no)[24], indicating that the program has been a success.
- Centres of Excellent Research (CER): The RCN has initiated a scheme called CER. The scheme will stimulate Norwegian research institutions to establish centres dedicated to long-term basic research of high international level, and aims to raise the quality of Norwegian research (www.forskningradet.no)[25].
- Centres for Research-based Innovation (CRI): The purpose of CRI is to build up and strengthen Norwegian research groups that work in close collaboration with partners from innovative industry and innovative public enterprises. The CRI arrangement promotes innovation by focusing on long-term research in close collaboration between research-intensive enterprises and prominent research groups. CRI develops skills at a

[23] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1228296770594&p=1228296770594&pagename=gassmaks%2FHovedsidemal
[24] http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1253963921794&pagename=FORNY2020%2FHovedsidemal
[25] http://www.forskningsradet.no/servlet/Satellite?c=Page&pagename=sff%2FHovedsidemal&cid=1224067001825

high international level in areas that are important for innovation and value creation (www.forskningradet.no)[26].

Through these and other venues there is also a flow of significant amounts to petroleum research, and these funds are more an open competition where everyone competes for the same funds (Reidar Müller, 2011). These independent research venues are mainly financed through a research fund administrated by the RCN. With the establishment of these programs the government have build up infrastructure and given incentives that increases the money invested into research & technology development. These programs gives many good incentive to petroleum companies and contractors giving them opportunity to participate in programs directed at solving problems and develop technology they need in their operations, while at the same time the risk involved is reduced by sharing it with the other participants.

4.3 Petroleum Companies

Petroleum companies involved in the resource extraction at the NCS are big players in technology development as they are very dependent on resilient technology. The companies use a lot of technology in their daily operations and are for the most part concerned with technology that is relevant for fields they operates. The petroleum business and especially the offshore side of it, is a very capital intensive business and huge investments are necessary to find and extract the resources. Enhanced technology better than the previous one are always welcome since they save petroleum companies' time and money, and thus each year petroleum companies invest about 3 billion NOK for petroleum research & development (Petoro Annual Report, 2011, p. 32). Competition at the NCS has undergone major changes since the late 1990's, and after the merger between the Norwegian companies Statoil and Hydro's petroleum business, Statoil has dominated the NCS. Statoil with near 80 percent of total production at the NCS plays an important role and in research & development. In addition there are a number of large international players who have been active on the continental shelf for a long time and that have ownership interests in the fields there. Big international companies are important players who with their experience and capital bring new impulses to Norway, and participate and contribute in research & development here. Since 2000 there have been over fifty new companies at the NCS both Norwegian and

[26]http://www.forskningsradet.no/servlet/Satellite?c=Page&cid=1224067021109&p=1224067021109&pagename=sfi%2FHovedsidemal

foreign, many of which are characterized as small, but still many have huge parent companies with significant financial strength backing them. In this thesis I have taken a closer look at two Norwegian oil companies, North Energy AS and Statoil ASA.

4.3.1 North Energy

The small oil company North Energy was established as recent as September 2007 as an initiative with roots in north of Norway. The company has an ownership composition where Norwegians own 65 percent of the company, UK 25 percent and miscellaneous Europe the rest 10 percent. North Energy has so far experienced a growth that is bigger than they expected, and with its initial northern-Norway funding this is quite impressive. In 2010 the company had equity of 480 million NOK, which is a huge increase since 2007 when they had 150 million NOK. Since the very beginning the company have built a portfolio of licenses in the Barents Sea, the Norwegian Sea and the North Sea, and by the end of 2010 they were part of 21 licenses at the NCS, but they only have operator responsibility on two of these licences. North Energy has four core values that shall characterize their business through their actions;

1. To be in front – innovative, alternatives, new ideas, solutions and technology, be the first to show the way
2. Competent – knowledge based on "state of the art", lead a good example
3. Bridge builder – to bring people together, point out the path, a preferred partner, focus and a facilitator
4. Fearless voice in the north – to be courageous enough to say what we believe is right and talk on behalf of the northern Norwegian community

North Energy has chosen to focus systematically on innovative solutions. Dense contact with the supplier industry and technological environments help the company optimize opportunities and plan for further research & development (North Energy annual report, 2010, p.6). North Energy's vision and objectives are based on that they can create a viable oil and gas industry in the north. Local effects and the environment are important aspects to them, and they are conscious of their role as manager of national resources and the environment. This is reflected in their outlook on development solutions. They state that they are searching for new technologies and innovative solutions that allow better utilization of petroleum resources, while they think long-term and seek the local impacts and ripple effects that are desired by those who will live with this in the future (www.northenergy.no)[27]. The company does not develop own technologies, and state that; “so far we use what others have developed, and that is good enough for us” (Knut Aaneland, 2011). North Energy does not have their own research facilities and he continues by saying; “We have to become quite a large company before we spend tens of millions on developing systems and technology ourselves. This is activities reserved the big companies”. Inge Carlsen (2011) supports this view by expressing that small oil companies are dependent on Joint Industrial Project’s (JIP’s), where several actors gather their research efforts, because alone they have limited funds available for research, but collectively they can achieve something. North Energy does not participate in any governmentally controlled programs or JIP’s, because they feel that it is too soon for this fresh company. They feel that the governmental programs are the contractors and big petroleum companies arena, but they receive many requests to be part of different projects from many different actors, but North Energy is at the moment holding back in fright of being involved in too many different activities and not being able to solve their core business properly (Knut Aaneland, 2011). At moment this small and still very young oil company has to concentrate all efforts at the exploration phase, that being seismic activity, drilling exploration wells, locating and mapping petroleum basins. Knut Aaneland (2011) emphasizes the importance of research & development efforts essential for the further development of the NCS. North Energy sometimes initiate research studies if there are topics they need to learn more about. E.g. exploring the potential development of a floating production unit/vessel (FPSO) -cluster off the coast of Helgeland carried out by the High North Centre at the University of Nordland. North Energy often uses local universities, Norut, Akvaplan-Niva, and others organizations to increase their knowledge. The University of Nordland have expertise in local value creation and ripple effects, but not on technology matters where they instead use e.g. the University College of Narvik as knowledge resource (Knut Aaneland, 2011). North Energy is as far as possible using companies with local ties to north of Norway for research & technology purposes and they cooperate with research institutes located in north of Norway as far as their partners competence reaches. Another character of North Energy’s innovative efforts is shown their willingness to think outside the box by using a combination of existing technology in a new and innovative way; to extract petroleum through a tunnel concept called “Eureka” (See figure 16 below). The Eureka concept consists of tunnels under the seabed leading to caverns where a land based drilling rig can be placed to

[27] http://northenergy.no/nb/var-virksomhet/utbyggingslosninger.html

drill wells to one or more fields. Petroleum can then be directed to an onshore plant via separate tunnels. Benefits of such a concept would greatly reduce drilling costs, avoiding interference with the fishing industry, avoiding harsh climate conditions, while at the same time eliminating the major risk factors such as discharges during drilling. The idea is not new and does not originate from North Energy as the idea was first discussed 20-30 years ago and was at the time called “PetroMine”. Back then the idea was generated in response to harsh climate and weather conditions, but was not adopted due to costs and technology constraints (Inge Carlsen, 2011). But the fact that North Energy is looking into such solutions for petroleum extraction confirms that the company has an innovative mode.

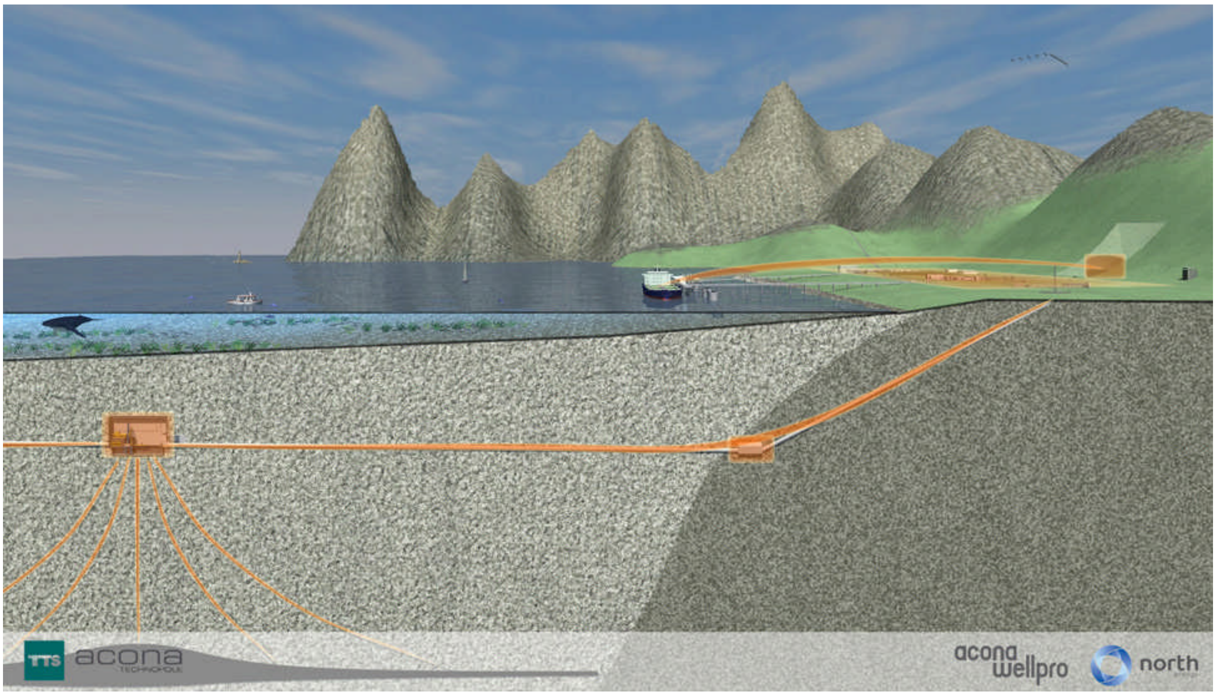


Figure 16 North Energy’s Tunnel Concept “Eureka” – (source: www.northenergy.no)[28]

The reason for initiating the Eureka concept came to life due to the report; integrated management of the marine environment in the Barents Sea and Lofoten (white paper nr. 8, 2005/2006). North Energy realized that there were many coastal areas that are relevant for petroleum extraction that would be opened in the near future. “The challenge is that these areas are vulnerable, so we were thinking that maybe there is a way to extract these resources without risking any spills into the sea” (Knut Aaneland, 2011). The company has together with Acona Wellpro done a comprehensive investigation of the possibilities and barriers of the Eureka concept and their conclusion is that the project is feasible. If the authorities decide to open up the areas of Lofoten and Vesterålen to commercial petroleum activities, North

[28] http://northenergy.no/en/our-business/development-solutions.html

Energy believe that the tunnel is a possible solution for these and other similar areas. According to Gøril Tjetland (2011) there has been a shift in the political views on the Lofoten and Vesterålen debate. In the white paper number 8 (2005/2006, p. 61) it was a treasured area that should be protected forever, but in the updated management plan of the Barents Sea and Lofoten (white paper nr. 10, 2010/2011, p. 67) the authorities have steered away from a zero-spill policy and total conservation. The political shift is that the authorities understand that the resources in these areas have to be extracted in the future, and that petroleum production have small emissions and need some wiggling room, if only a little. The biggest emission risks are connected to petroleum transportation and not petroleum production. The society seems to have the perspective that it is not possible with today's technology to extract these near costal resources at an acceptable risk and thus the petroleum industry need to follow this up by presenting new ideas and solutions that can reduce the risks even further. This is part of what North Energy has tried to do by looking into the opportunities that lies in the Eureka concept.

4.3.2 Statoil

Statoil was established in 1972 under the name "The Norwegian's States Oil company A/S" as a fully state owned corporation, and at the time had a number of political considerations to take throughout its business. The company grew rapidly which lead to the establishment of SDEA under the management of Statoil and its subsidiary company Petoro. Statoil could after this conduct its operations with more emphasis on business and less on politics and thus could behave more like a private company. Today the company operates on commercial terms as other private companies throughout the world, without having to take political considerations. Statoil is a very dominant player at the NCS in all phases of petroleum operations. The company held by the end of 2009 interests in 219 production licenses and was operator for 42 producing fields. The company operates fields that together make up about 80 percent of petroleum production at the NCS. Statoil is also likely to allocate about one-third of the remaining resources at the NCS (report from the Extraction Committee, 2010, p. 31). According to Cato Willie (2011), former chief researcher for Ideas and Innovation Management at Statoil; technology is of key importance to Statoil because technology is an enabler for business development in Statoil and they use approximately 825 million NOK each year on corporate research & development activities. Statoil is committed to research, technology and expertise to fulfil its ambition to become a stronger and internationally

competitive company (www.statoil.no)[29]. Thus Statoil's research is organized into different programs within the value chain, in addition specific business challenges related to the Gulf of Mexico and oil sands in Canada:

- **Exploration:** Generate technologies and knowledge that will create new opportunities and strengthen positions in key exploration areas
- **Increased Recovery:** Improved reservoir models, new production methods and new drilling and well solutions to reduce cost
- **New field development solutions:** Develop technology for cost-effective realization of the challenging oil and gas fields
- **Oil-Gas Value Chain:** Research is necessary for the facilities in operation
- **New Energy, Health, Environment and Safety:** New forms of energy with a focus on offshore wind and second generation bio fuels, safety, and Co2 storage
- **Gulf of Mexico:** Get the necessary technologies quickly and profitably
- **Extra Heavy Oil:** Energy-efficient and good manufacturing solutions for the oil sands in Canada, and other onshore facilities
- **Laboratory and Test Facilities:** Operating and developing laboratories and test facilities, including test centre at Mongstad

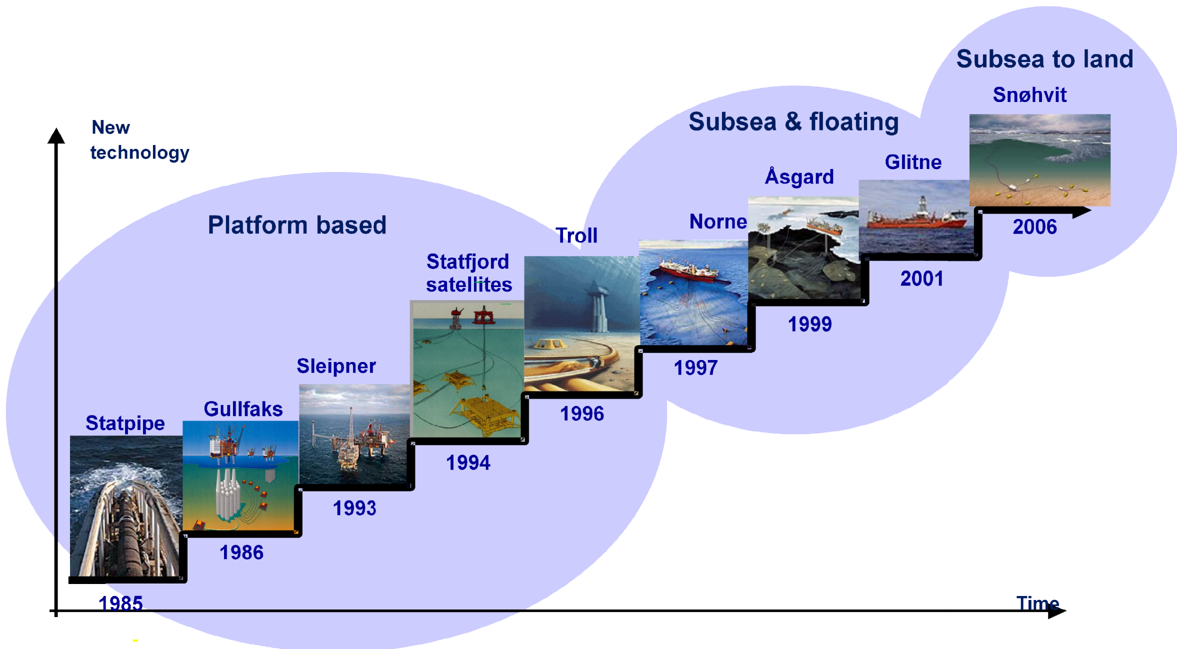


Figure 17 Field Developments at the NCS (Source: the Extraction Committee, 2010)

[29] http://www.statoil.com/no/technologyinnovation/researchinstatoil/Pages/default.aspx

Statoil has over the years been part of developing technology and the figure above illustrates how field development has changed operations over the last 25 years from platform based technologies, via subsea & floating to technology developments related to the Snow White field. In addition to the field development technology Statoil's focus on innovative development has given other results; Statoil operated fields have among the highest recovery rates in the world, and also the cleanest extraction of petroleum when it comes to emissions of green house gasses. In order to meet the needs for innovations it seems Statoil first try to take advantage of external expertise and thus they have developed an own separate website (www.innovate.statoil.com)[30] that function as a point of contact between Statoil and creative forces inherent in the industry. At this website contractors can read about Statoil's seven main technology areas that are of particular interest for development and innovation; exploration, reservoir, drilling and well, new field development, processing and refining, environmental and new/renewable energy. These are the same focus areas mentioned earlier except from the exclusion of the Gulf of Mexico, extra heavy oil, and laboratory operations. At the website there is also presented three concrete challenges that they need solved: Plug & Abandonment, Subsea Technology, and Sub-basalt exploration. The concrete problems are only on the webpage for a limited time and new challenges are presented from time to time. The website also provides opportunities to submit general ideas to all parts of their business and not only limited to Statoil's suggested areas.

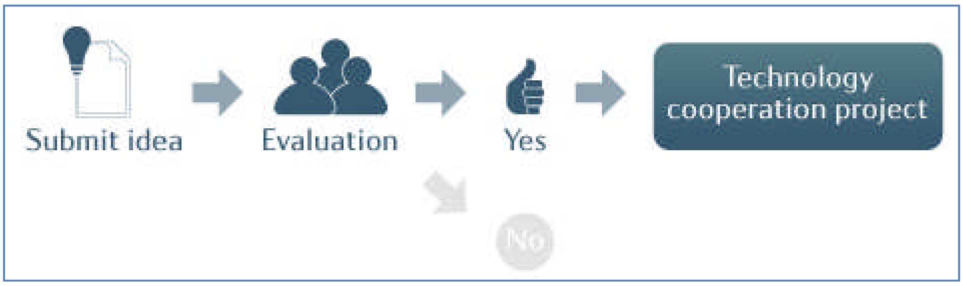


Figure 18 the Process of Teaming up with Statoil (Source: www.innovate.statoil.com)[31]

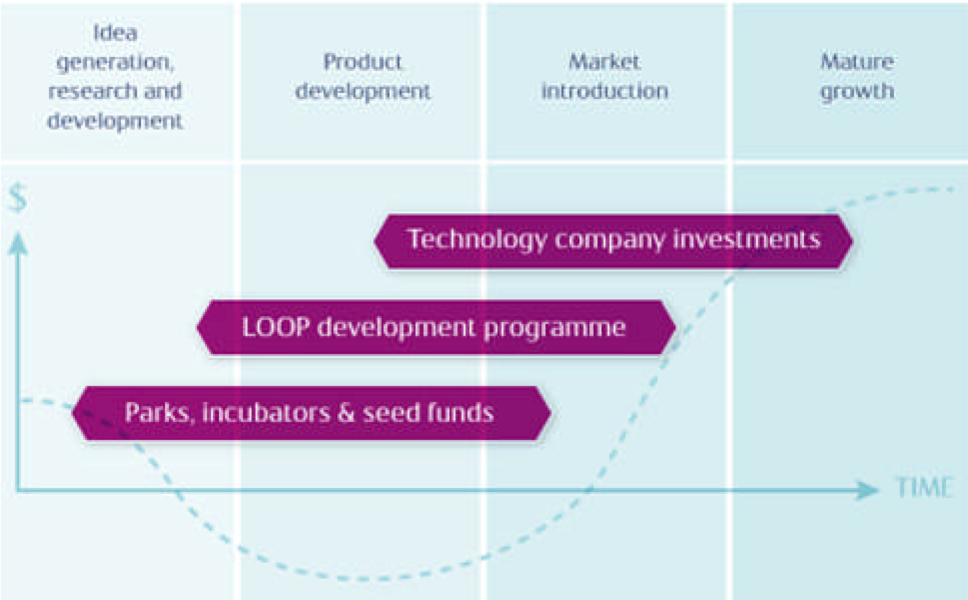
In the figure above the general path towards technology cooperation with Statoil is illustrated; Received ideas are evaluated and if approved they enter into a cooperation with the developer(s) of the idea. The petroleum company is interested in connecting with creative forces that might present new ideas or fresh perspectives to old and new challenges they face, and thus engages in projects with entrepreneurs and industrial companies in order to help new

[30] http://innovate.statoil.com/Pages/default.aspx
[31] https://innovate.statoil.com/_layouts/statoil.innovate/forms/ideasubmission.aspx

and emerging technologies reach the market. Once committed Statoil can offer participation in:

- LOOP, a program for product development (www.innovate.statoil.com)[32] which contributes with advice, financing, networking and potential pilot applications in technology development and verification projects
- Parks, Incubators and Seed Funds, which is their support of early-phase technology development. Statoil has ownership positions in several of these across Norway (See appendix 3).

In this way they offers funding for development projects, but at the same time they have also set a minimum demand that applicants need to show commitment by providing parts of the funding themselves. The petroleum company do not commit themselves to buy the end-product and the technology developer(s) has to compete for deliveries on equal terms with other developers. Statoil also invest in companies with unique technology and high growth potential in the petroleum and new/renewable energy sectors (www.innovate.statoil.com)[33]. The figure below sums up Statoil's technology efforts where their investments in development projects become more intense as the end-result is getting closer to the market. In their efforts they have particular focus on the development phase and the commercialisation phase of innovation. This includes detailed product development, prototyping, testing and verification, and market planning (www.innovate.statoil.com)[34].



[32] http://innovate.statoil.com/about/Documents/Fakta_LOOP.pdf
[33] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx
[34] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx

Figure 19 Statoil's technology efforts through external forces (Source: www.innovate.statoil.com)[35]

At Statoil they have a special unit within the division of technology & projects that has been given the responsibility for commercializing technology, and establish & develop industrial and commercial activities. Developed and successful technology has to be made available through the company's network of suppliers, and the technology often requires establishing new, entrepreneurial companies. The establishment of new companies is sometimes done for simplicity of the commercialization process; in addition Statoil has a strategy of not being a long-term investor. Thus the new company that now has the responsibility of the new technology that are (partly) owned by Statoil, will eventually be sold when the business is running smoothly. One example of this is the geophysics company EMGS that started out as a cooperation between Statoil and NGI. Said very short the EMGS's revolutionary technology involves sending electromagnetic waves into the ground in order to determine if there is petroleum present. The technology was developed and tested with positive results which led to the establishment of the EMGS company that later was sold to the investment fund Warburg Pinicus for some hundreds million NOK (www.forskning.no)[36]. For more examples of Statoil spin-offs see appendix 4.

Statoil have also its own research facility which was established and developed between 1991 and 1994 with a clear open innovative mindset (Cato Willie, 2009). The location at Stjørdal is not chosen coincidently as it has close proximity to the Norwegian University of Science and Technology (NTNU) in Trondheim. At Stjørdal Statoil's research efforts have been gathered, but exactly what research they do there is a layer that has not been possible to pierce in this study because Statoil chose not to participate in this study. This is a surprise as one of their main issues with the open innovative mindset was to avoid a closed technology fortress (Cato Willie, 2009). According to Inge Carlsen (2011) the petroleum companies can be quite arrogant as they feel they know best, but this can lead to a closed research environment. The research centre at Stjørdal is an example of this as there is little people know of what is going on there (Inge Carlsen, 2011). The information that has been gathered for this thesis has not given unambiguous indications of the activity at Stjørdal and thus I can only speculate in the data available. From the data I derive that Statoil as much as possible look outside their own organization to utilize creative forces in the industry, and beyond, to solve difficult challenges, thus stimulating innovative efforts and not so much starting their own

[35] http://innovate.statoil.com/about/Pages/Process-and-benefits.aspx
[36] http://www.forskning.no/artikler/2008/januar/1200389007.81

development endeavours. At the web-page that works as a contact point with creative forces; all but three of Statoil's prioritized research areas are highlighted there. Only the Gulf of Mexico, extra heavy oil, and laboratory operations are not mentioned there, thus one can be lead to believe that this is the activities that Statoil is conducting at their Stjørdal research centre. The reality is however more complex and they probably do much more there and especially research & development that they do not want to share with the public.

4.4 Contractors

The contractor industry makes a living out of selling their products to the petroleum industry, both technology products and services. They contribute directly in the process where they create products that later can be commercialized, creating value for the companies involved. The initial idea may either come from inside the contractor company, or they can be approached by a petroleum company that want their help in some respect. The FNI is a member association which organizes 2200 member companies (contractors) with 125.000 employees. They provides their members with legal advice related to being an employer and gives assistance in different issues mainly within; HSE, expertise and industry relationships (www.norskindustri.no)[37]. The FNI has several branch associations where one is the branch for oil and gas. According to Runar Rugtvedt (2011) "The FNI is a branch association that works toward stable and favourable working conditions in the petroleum sector in Norway. Our goal is that Norwegian contractors shall be in front when it comes to technology and development, and that they have products that are top-class, and that the products are attractive both at the NCS and the international market". Each year the board in the Oil and Gas branch at the FNI create a yearly action plan for research & technology development that works as the foundation for the next year's activity. This plan is then forwarded to the member companies in order to give incentives related to specific priority areas etc. The FNI stimulates their members to be creative, to think outside the box and to find new solutions (Runar Rugtvedt, 2011). The FNI hosts member meetings were the petroleum industry presents challenges they face, member companies inform about what they are developing and how they are cooperating with one and another, and the research sector presents what they are concerned with. At these meeting the opportunity to become more unified in their efforts are present. The FNI also works toward educational institutions as well. They arrange what they

[37] http://www.norskindustri.no/om-norsk-industri/kort-om-norsk-industri-article3058-73.html

call a ‘petroleum day’ at universities, where they use one day to discuss oil, gas and renewable energy with the teachers and students. They also have a program directed towards primary and secondary schools were they inform about the industry.

There are many contractors that works and deliver products to the petroleum industry at the NCS, both Norwegian and foreign. Schlumberger is a foreign company that operates in Norway, and in fact Schlumberger and their subsidiary Western Geco invest more in innovations & technology development at the NCS than the Norwegian government (Report, Petroleum Research Pays Off, 2005, p.12). The contractor industry have small margins and not so much funds to put into research & development in comparison to petroleum companies, but the FNI have noticed that more contractors are now setting aside higher amounts to technology development to be in front. The contractors use about 1 billion NOK each year on research and development (Petoro Annual Report, 2011, p. 32). The petroleum companies have quite good conditions at the NCS for developing technology in projects as they have a favourable tax regime, depreciation arrangements, return of cost etc. This has resulted in many projects that have naturally rubbed off to the contractor industry since the petroleum companies hires contractors to their projects. This is favourable for the contractors since they do not have the same advantageous tax position etc. as the petroleum companies. According to Runar Rugtvedt (2011) the contractors have intense collaboration in the process of innovative development with the rest of the stakeholders at the NCS. “In Norway we have developed clusters of expertise who have become very good in different technology areas. One example are the sub-sea cluster where 70 percent of the world market is run by three companies with their seat in Norway, with SMC in front, and Aker Solution and General Electric as second and third. There exists a drilling cluster in the south of Norway with EMC as an umbrella organization; this is a huge success as they export 90 percent of their technology. Another cluster is the called the Møre-cluster within the maritime oil and gas, where the Norwegian shipping environment has the most advanced and newest fleet built with the help of designers and ship yards located in Norway and who are amongst the biggest in the world” (Runar Rugtvedt, 2011). In addition to these already established clusters, the interview with North Energy gave information that indicates the potential of another cluster being developed with high expertise in Floating Production Storage Units (FPSO) at the coast of Helgeland.

4.5 Research Institutes

One of several key factors behind the creation of value that have taken place during the Norwegian petroleum era is the focus on petroleum related research & technology development and a willingness to learn. The competence built up over time is in many ways an inconspicuous but decisive factor in the Norwegian petroleum success. The Norwegian research environments that exist today have gradually built up competence and knowledge relevant to the NCS and the challenges the industry faces. Important research institutes that do petroleum related research & development are Rogaland research, Christian Michelsen Research, Institute for Energy Technique, SINTEF, the International Research Institute of Stavanger and Norwegian Geotechnical Institute whom all have their own speciality areas (report, Petroleum Research Pays Off, 2005, p. 16). In addition to these research institutes there are a lot of other efforts like CER and CRI that all contribute to the research and development efforts of technology at the NCS. This list is not by any mean exhaustive but only provides some examples of the research institutes that are working in this area.

SINTEF is another example of a research institute that also do petroleum research. SINTEF is Scandinavia's largest independent research group that create value through knowledge, research and innovation, and develops solutions, and technologies. The SINTEF Group comprises the SINTEF Foundation plus four limited companies and SINTEF Holding. One of the four limited companies are SINTEF Oil and Energy, that comprises of SINTEF Petroleum research limited and SINTEF Energy limited, that works with research along the whole value chain of petroleum products and sustainable energy systems (www.sintef.no)[38]. SINTEF petroleum research has built up their competence in finding resources, basin modelling, drilling, and reservoir recovery, thus for the most part in the upstream parts of the petroleum value chain. According to Inge Carlsen (2011) there are three ways research institutes get involved in technology developments at the NCS; first they can themselves produce ideas, preferably in collaboration with the petroleum industry, second they can apply for funding through the RCN, and third the industry might approach them with ideas where they want them to illuminate certain themes through research. One example from 2009 is when SINTEF conducted a quick study related to well-security on behalf of the NPD. This example, were the 'employer' is the authorities, is not very typical. Because as Inge Carlsen (2011) states; 90 percent of their research is directly financed by the industry, and only 3 percent comes from public funding to independent research, which he of course thinks is too little. The amount of

[38] http://www.sintef.no/Om-oss/Organisasjonskart/

independent funding is dependent on how big turnover the research institute had and the results of their research. SINTEF has formed partnerships with different stakeholders at the NCS, like NTNU and the University of Oslo. Personnel from NTNU collaborate in SINTEF projects, and SINTEF employees teach at the university. An extensive joint use of laboratories and equipment further characterise the collaboration between them (www.sintef.no)[39]. In order to secure a high level of expertise University collaboration has a high priority in the SINTEF group.

4.6 The Community

The last category of stakeholder is not as uniform as some of the other groups of stakeholders, as there are several and quite different sub-groups assembled within this term. Fishermen, local shop owners, environmental interest groups, animal-rights groups, non-profit organizations, etc. all fits into this group. The community as a stakeholder of the petroleum industry often express their opinions and in this context for the most part related to fear of consequences of further development of the petroleum industry. The biggest concerns for the community stakeholders are:

- Spills or leaks can destroy the environment and wild life/marine life
- Petroleum facilities onshore increases risks by that they handle hazardous chemicals/materials that can threaten water supplies, takes up industrial space, and pollutes the environment
- Offshore installations at sea often create conflict with another very important industry namely the fishing industry; local fishermen can no longer drive their boats where they want, while the petroleum activity might affect the fish population

In sum the community stakeholders view the petroleum industry with scepticism because their own interests are threatened or may get negatively affected by the petroleum activity in the future; either it is inhabitants who like to have a stroll at their nearby foreshore where an oil spill will result in loss of recreational opportunity, or local fishermen losing fish or fishing fields due to petroleum activities. For these reasons the community stakeholders tend to work against the development of the petroleum industry. The petroleum industry does not have the best reputation around the world when it comes to complying with community stakeholder's

[39] http://www.sintef.no/Om-oss/

point of view. So it is easy to understand how difficult it can be for these stakeholders to get their voices heard by an industry that is perceived as strong and difficult to influence and pierce through. The fear is based in the belief that petroleum companies only follow their own agenda and will not take any considerations unless pressured. To be able to pierce through petroleum companies, community stakeholders tend to organize themselves in order to be stronger and more visible. Only when people in communities around the world organize their efforts collectively they can hope that they are able to take a stand against big, strong, and strategic corporations. One example of these diverse stakeholders is independent non-profit organizations like Bellona, whom works to increase the ecological awareness in the community to prevent pollution and mitigate climate change that affects people's health and the environment. Another example is the political grass root organization 'Peoples Action for an Oil Free Lofoten and Vesterålen' (www.folkeaksjonen.no)[40] where people with same viewpoints come together to work towards a common goal; to fight for a permanent petroleum-free area offshore Lofoten and Vesterålen. In order to get their opinions and perspectives communicated these stakeholders typically try to exploit the networks that they have and they are in constant dialog with other organizations, businesses, media, researchers and politicians. Public relations and information exchange is thus important and the interest-groups are also publishing their own technical reports, notes and magazines. By expressing their opinions through their communication channels the community stakeholders tries to achieve as much influence as possible over people and decisions that is to be taken. In some extreme cases the community is able to exert such a strong pressure on a petroleum company that it is forced to respond and change in some respect. One example of this is the Esso consumer boycott in 2001-2003 that changed the shareholders opinions, and in the end the company's perspective on climate change (Gueterbock, 2004). The Norwegian example is seen in the debate of petroleum operations in the areas of Lofoten and Vesterålen were the community has been part of making it a political issue, which has resulted in postponement of further petroleum activities in these areas.

In this way they are been able to have some influence amongst the other stakeholders and can not be taken for granted. There are of course stakeholders in the community group that work together with the petroleum industry, because they recognize the positive impact the settlement of the industry bring with it. The freshest example of this in Norway is found in Hammerfest where all inhabitants embraces the industry, an industry which has made the city

[40] http://www.folkeaksjonen.no

of Hammerfest grow and that have added needed capital to the region. In Norway the attention for the community stakeholders has not been very imminent, mostly because the petroleum installations are far out in the sea and not noticeable in peoples everyday lives, except maybe in few parts of Norway. Further there have been few accidents in Norway and no big ones that have impacted the nature or marine/wild life irrecoverable. Not to say that these stakeholders haven't made protests etc, or been taken into consideration, only that this is becoming a more important aspect of the petroleum industry at the NCS and to the rest of the world's industries for that matter. As the petroleum industry is moving further north the community stakeholders 'cause' grows stronger since some of the present and coming fields will be located in vulnerable and near coastal areas. Recent spills like the "Deep Horizon" accident in the Mexico Gulf together with the increasing global awareness regarding climate changes makes this groups' presence meaningful, relevant and important.

4.7 The Process of Innovative Development

4.7.1 A Need or Recognition of a Problem

There are several reasons why an innovative process is kick-started and innovative efforts are set in motion at the NCS. From the very beginning the companies that operate at the NCS have literally been thrown into the deep end as the offshore environment is hostile and the resources hard to reach. Hence innovativeness has always been necessary to access resources at the NCS. "In Norway we are operating at deeper waters, we have more pressure, higher temperatures, more difficult drilling conditions, thus it is quite typical that innovative projects are initiated as a result of the huge challenges at the NCS. One example of this is the Ormen Lange field where they now are running a pilot on gas compression. The Ormen Lange field and many with it are experiencing lower pressure in the reservoir which leads to lower production. As the reservoirs are maturing and production has reached the tale, they need to continue developing the field to keep the production as high as possible and as long as possible" (Runar Rugtvedt, 2011). He further mentions challenges related to new findings as another generator for innovativeness. The harsh conditions in the seas outside Norway and the current profile of the NCS have naturally lead to higher costs, which is an attribute associated with the NCS; the extraction costs there are much higher than other places in the world e.g. the Middle East. Thus research & technology development that contribute to cost reductions are always very welcome. "The industry is very cost conscious because of the huge investments that is required, so research that is cost reducing, effective, and cheap have the highest focus in petroleum companies" (Inge Carlsen, 2011). Petroleum companies are always looking for new and more effective ways to do their operations like IOR/EOR, more effective drilling, cost reduction and acquiring licences. According to Inge Carlsen (2011) "...in the acquiring of licenses the companies are measured by their technology and what they are capable of accomplishing". Technology development may also be brought about by demands and regulations from the authorities; safety and environmental regulations and other provisions and influences. New ideas for innovations can in theory come from any stakeholder of the NCS; the petroleum companies, contractors, government, universities and research institutions. The contractors are in close contact with the petroleum industry and knows it well, and with this knowledge contractors can sometimes produce own ideas for technology research & development projects that can help mitigate the challenges the petroleum industry faces. But according to my respondents it is quite rare that it happens this way because contractors, or other stakeholders, are normally approached by a petroleum company that hires them for a contracted job. This is confirmed by Bente Nyland (2011) who states that; "the petroleum companies contact the contractors and the contractors do not do much unless the petroleum companies hire them". Historically the contractors have had small margins and not so many resources available to put into research & development, but according to Runar Rugtvedt (2011) more contractor stakeholders put aside money for research & development and use these money to develop their products and services. Contractors are almost always dependent on the goodwill of a petroleum company for demonstration, and this acts as a barrier to more research & development of technology. Research institutes tries to come up with own ideas for good research & development efforts, and often in collaboration with the petroleum companies. Research institutes may also get involved by applying participating in authority programs and recieve funding for research that way, or applying for the limited amount set aside for independent research. But according to Inge Carlsen (2011) there is too little independent research funds to apply for. SINTEF only have 3 percent of their funds to use on independent research where they decide themselves the scope. There is no reason to believe that the situation is different in any of the other petroleum related research institutes/divisions in Norway. In practise at this stage, before the 'go ahead' has been given for innovative endeavours, the community may highlight technology that is more environmental friendly or they can highlight problem areas or risk areas that need improvement and voice their concerns over outdated technology that is in use etc. Bellona has such gravity that they take part in governmental hearings and hence have a clear path to express their opinion before any major decisions are taken, and thus have some influence on political decision processes. As the community is standing on the outside, so to speak, and is not participating directly in innovative development processes they have were few options other than expressing their opinion and spreading their message to make their potential influence greater. In this way they can manage to create a strong external pressure so that their viewpoints are considered in the decisions processes. Besides this there is no other action they can take to on their own to kick start, or stop, an innovative process in relation to the petroleum industry.

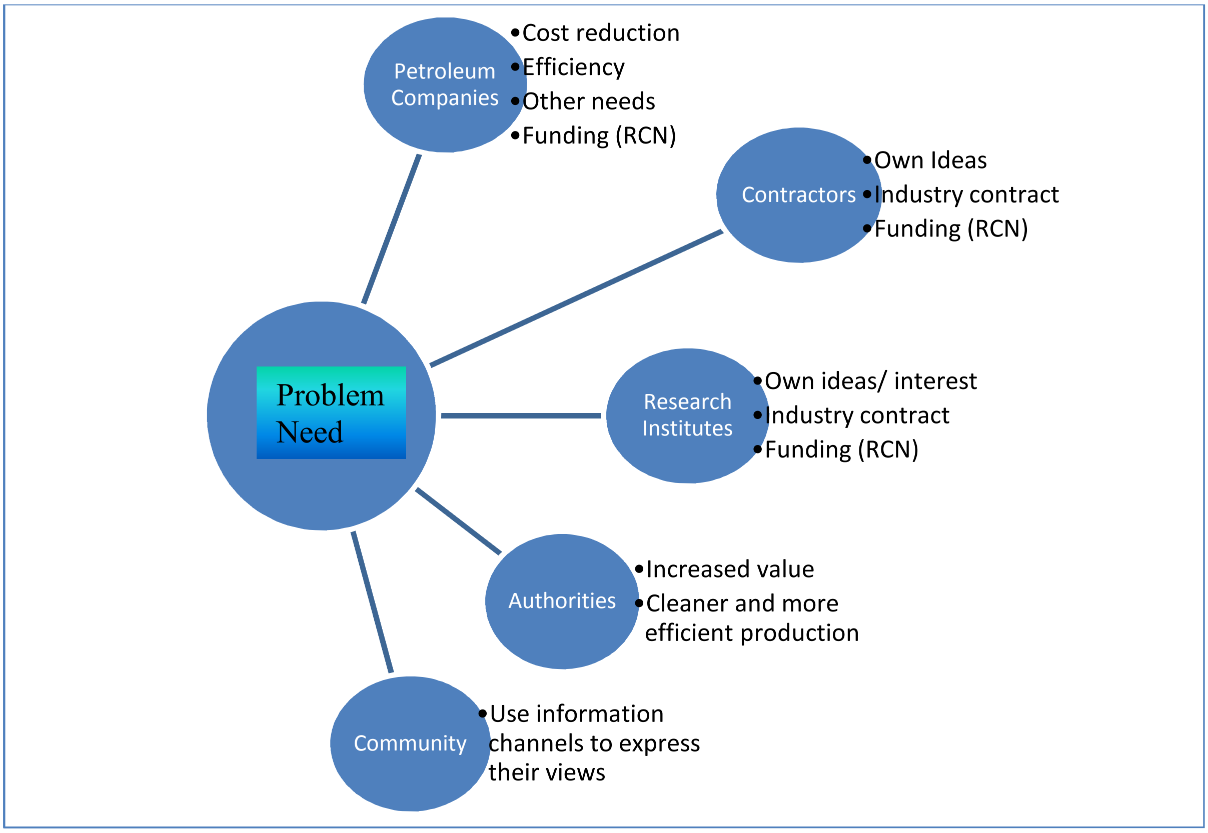


Figure 20 First Stage in the Process of Innovative Development with Stakeholder Entrance

The figure above tries to sum up the entrances and perspectives each stakeholder have to entering a innovative development process. The big bubble is representing the first stage in the process and the different stakeholders is presented by the smaller bubbles, while each stakeholders possible entrances is put in bullpoints.

competitive company (www.statoil.no)[29]. Thus Statoil's research is organized into different programs within the value chain, in addition specific business challenges related to the Gulf of Mexico and oil sands in Canada:

- **Exploration:** Generate technologies and knowledge that will create new opportunities and strengthen positions in key exploration areas
- **Increased Recovery:** Improved reservoir models, new production methods and new drilling and well solutions to reduce cost
- **New field development solutions:** Develop technology for cost-effective realization of the challenging oil and gas fields
- **Oil-Gas Value Chain:** Research is necessary for the facilities in operation
- **New Energy, Health, Environment and Safety:** New forms of energy with a focus on offshore wind and second generation bio fuels, safety, and Co2 storage
- **Gulf of Mexico:** Get the necessary technologies quickly and profitably
- **Extra Heavy Oil:** Energy-efficient and good manufacturing solutions for the oil sands in Canada, and other onshore facilities
- **Laboratory and Test Facilities:** Operating and developing laboratories and test facilities, including test centre at Mongstad

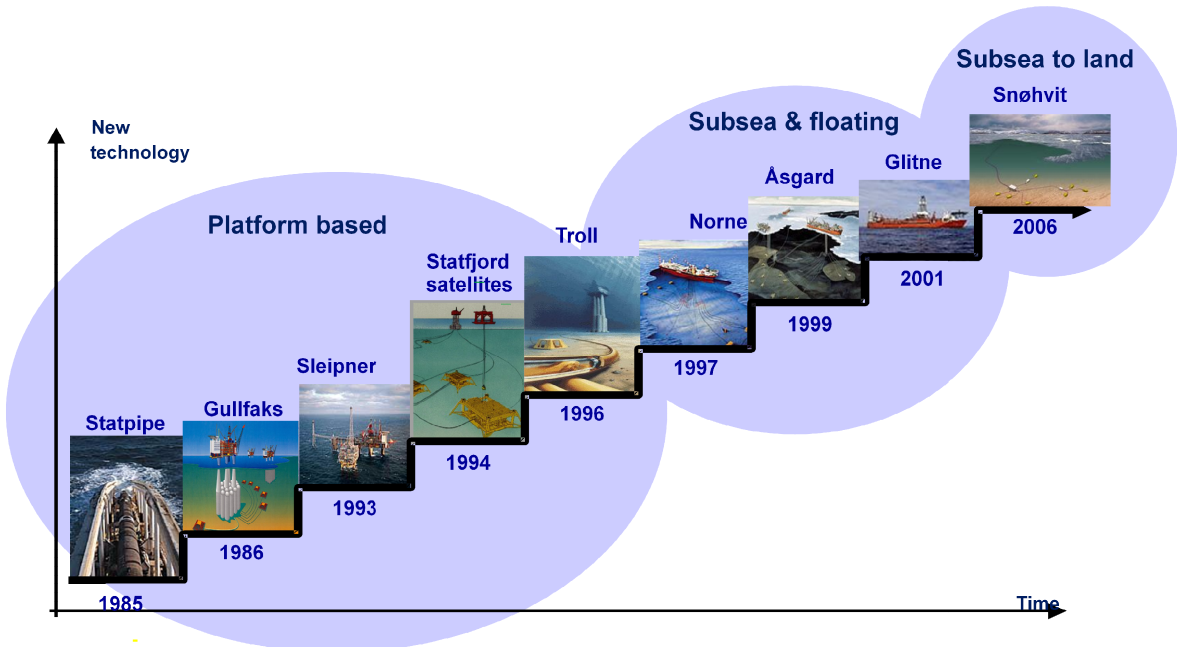


Figure 17 Field Developments at the NCS (Source: the Extraction Committee, 2010)

[29] http://www.statoil.com/no/technologyinnovation/researchinstatoil/Pages/default.aspx

Qualification carried out under the governmental program DEMO2000 and under the auspices of petroleum companies in collaboration with their partners are done physically onshore and at offshore fields. “The qualification of technology is about the companies testing and re-testing a component in order to be sure that the component works under right conditions, because if something fails or is destroyed after implementation at a field the costs involved are that much higher. The requirements for qualification are for the most part set by the petroleum companies to the contractors who develop the technology component. The approval is only done when the petroleum company is absolutely sure that the component works properly and under the right conditions” (Knut Aaneland, 2011). This kind of testing of technology physically at offshore fields requires the goodwill of a petroleum company, and is a collaborative effort between petroleum companies and their partner(s). According to Reidar Müller (2011) one thing they have often heard from the industry is that; “it is challenging to qualify enough new technology at the NCS at the moment. Statoil feel they do enough and have a lot of pilots, but others feel they are not doing enough”. Gøril Tjetland (2011) has the same viewpoint; “the challenge seems to be qualification and implementation of new technology”. Knut Aaneland (2011) states that; “it is imperative that we do not come to a point where the contractors develop something, and when they have a prototype that is no petroleum company that is willing to spend time or money on qualifying it. But so far at the NCS we have had big international petroleum companies that are willing to spend time and money in developing new technology and qualifying it”. The profile of the NCS has also played a role since few new big explorations have been made and developments of existing fields are low. This hinders both development and qualification as there aren’t any big fields like Ormen Lange that can cover the costs related these tasks. A new big discovery like Johan Sverdrup gives hope of more similar findings, since field of this size, and bigger, yields economic power that allows for development and qualification of technology.

4.7.4 Commercialization of Technology

When the innovation is through the qualification stage and has proven that it function according to specifications it is time to commercialize it, make it known, make it available as a product or service and win over potential end users. This is done by showing the products results from testing regarding quality and functionality to as many potential end-users as possible. In Statoil they have a designated unit that has the responsibility for commercializing technology and establish and develop industrial and commercial activities. Statoil have in the figure below shown the important aspects and things to think through in the commercialization process the way they see it.

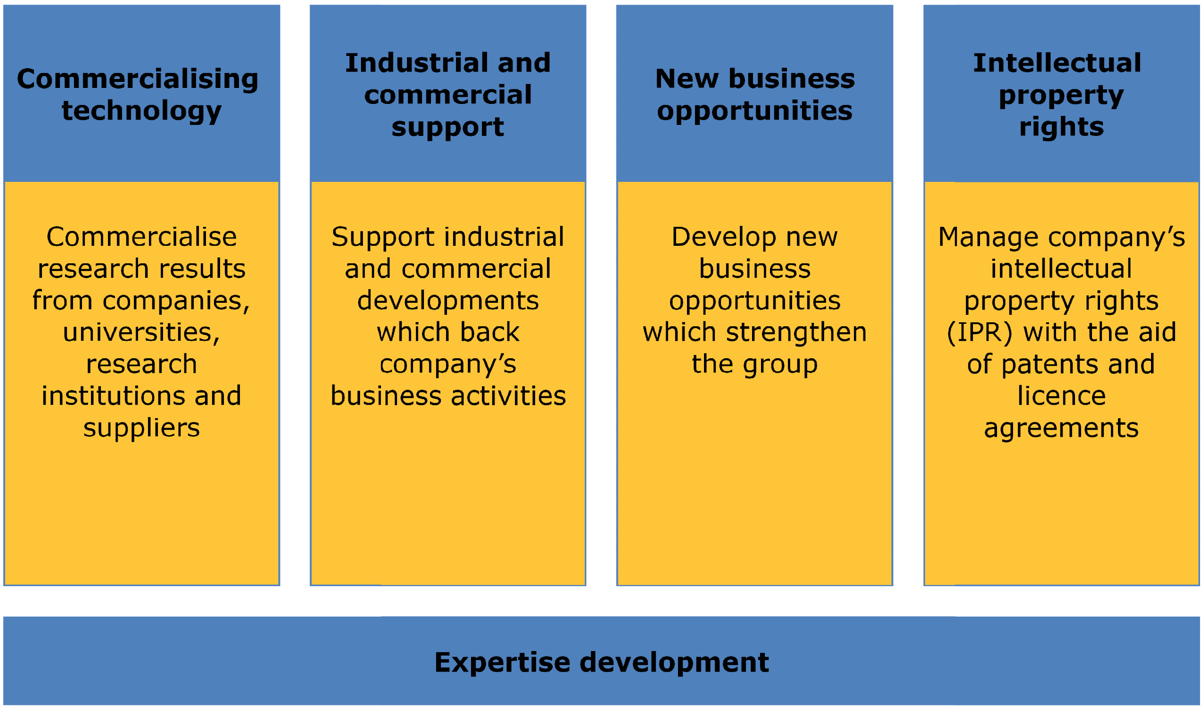


Figure 21 Cornerstones in the Commercialization Process (Source: Cato Willie (2011)

The first thing one has to do is to use the network you have to make the product or service known and available which can be done at exhibitions, trade shows, industrial arrangements, media, etc. The goal is to advertise the innovation by to make their product/service well known for its application and benefits and to receive support within the industry. Another important aspect that should be considered is if the technology should be commercialized through the existing company (companies) or if the product should be separated and commercialized through a newly established company. Often it is more functional to separate the innovation into its own company. It is important to think of patent rights before the product is released onto the market because you want to protect and manage the ownership of the innovation to realize maximum value, securing income to cover costs and profits. Another reason to think about patent is that during the patented period no one can sell copies of your product, thus maximizing revenue. "The Norwegian subsea contractors are very thorough when it comes to take out patent rights to make sure that no one else is producing their products as their own" (Knut Aaneland, 2011).

4.7.5 Diffusion and adoption of innovations

When I started this course I had a presumptive assumption that petroleum companies that possessed a ground breaking piece of technology would keep this a secret to give them a competitive advantage over their competitors. This assumption is for the most part wrong when it comes to the petroleum industry. The upstream business is divided into two phases the exploration phase and the production/operation phase, and there are some differences in these two phases when it comes to motivation to share knowledge between competitors. “In the phases of production, drilling, field development and well safety the industry have recognised that they benefit from sharing their experiences. And according to Bente Nyland (2011) will those who have developed an innovation see the business potential in it and thus want to spread the innovation to as many as possible. In the exploration phase there is much more secrecy related to how to interpret seismic data, and the big oil companies do a lot of their own research which they do not share with others” (Inge Carlsen, 2011). This is confirmed by Bente Nyland (2011) who states; “The biggest competition between petroleum companies at NCS is in the exploration phase when you compete about licences. In this phase it is important to have a competitive edge over you competitors, and in such an environment it is almost impossible to have an open and sharing research environment”. She further states that the competitive edge is knowledge. In order to interpret the data (seismic and other) the analysts use computer programs, modelling systems, and other analytical tools which often are made inside the company. Hence this kind of knowledge is kept secret as it can give a competitive advantage in the acquiring of licences and tenders. That is only if the knowledge they possess give them better understanding of data and reservoirs than their competitors. Reidar Müller (2011) also confirm this when he stated; “technology for exploration like seismic and other ways to acquire data is open and available to everyone, but the way they work with and interpret the seismic data is kept as well guarded secrets”. Thus there is a distinction in the level of secrecy in the exploration phase, between technology for acquiring data, and knowledge and creation of programs that interpret the exploration data. Apart from this my understanding is that there is little secrecy or competition related to technologies in the petroleum industry in Norway, and according to Inge Carlsen (2011) technology spreads fast after it has proven its capability and become qualified. “For contractors the competition is more related to the phases of field operations and field development where they compete for tenders” (Bente Nyland, 2011). Some companies may have technology that they do not want to share with other, but in such cases ‘lookalike’ innovations will soon pop up in the market. Most companies that develop a product at the NCS do not only consider operators in Norway as potential clients, rather most producers are interested in exporting their components throughout the world. The Norwegian authorities also see export of technology as a target in their OG21 strategy. To be able to accomplish this, the developer has to deliver quality in order to be able to compete internationally. Considering the different technology clusters that have developed in Norway and whom are in top of their class worldwide indications that technology developing stakeholders of the NCS have not had problems to compete on the international market, rather they have thrived and grown.

4.8 Technology requirements at the NCS

In Norway there are no specific requirements to what technology to use in petroleum operations, as the authorities only set so called functional demands to companies that operate at the NCS. Functional demands are requirements of what the companies have to do and be able to do at the areas they are awarded without any specified technology specifications. According to Bente Nyland (2011) “There are no requirements related to technology in the exploration phase, only to competence and exploration strategy. In the extraction phase there are only requirements for safe and optimal solutions. In certain areas of field development there are demands to usage of the best technical solutions available (BAT), but in general we only have expectations to usage of the best technical solutions available, and we also ‘reward’ such utilization”. When a company have found petroleum and the field is to be developed they need to apply for operator rights by showing how they want to develop the field, operate it, abandon it and what consequences this has on the environment. Hence those who have ambitions to be awarded a license at the NCS and operate there need to apply through a Plan for Development and Operations of petroleum deposits (PDO). In response to these applications the authorities thus have a possibility to use their influence and set some requirements to the applicants; like that they want the operator to implement a purification element, or inject CO2 for IOR, power from onshore, etc. Later Plan for Installation and Operation (PIO) gives permission for installation and operation of facilities – often intended for transport of petroleum (guidelines for PDO and PIO, 2010). The government receives many applications for each field and approve the application with the most optimal and safe solution. No too specific requirements only functional demands. According to Gøril Tjetland (2011) setting demands in these application rounds has not been very successful as the government is not using its full power to persuade the operators. Another requirement under the functional demands are Best Available Technology (BAT) which originates from an EU directive (www.regjeringen.no)[41] and according to Runar Rugtvedt (2011) "The BAT arrangement sets demands that everything that is going to be used shall meet the safety regulations, be in acceptable condition, and have proper functionality". This regulation enables petroleum companies to choose technologies and procedures that they see fit for the operations they are in charge of, but at the same time this entails more responsibility as they are held accountable for their actions and choices. This is supported by Bente Nyland (2011) who states that; "The authorities do not have any competence to determine what technology that is best to utilize, the companies are made responsible for the implementations of technology and other solutions they chose in their petroleum activity. In relations to e.g. implementation or changes, the authorities only check if the proposed solution is safe and if it looks like the optimal solution. But they never say that to run this operation you need to use this or that technology". According to Gøril Tjetland; "The Norwegian Veritas (DNV) has made a way to sort technologies in relation to BAT. The scale goes from 1 which is well tested and used technology, to 4 which is new and untested technology. The problem with this scale is that it does not take into account the potential of the technology. One technology that is not so well tested may get a bad score even though the potential may be increased performance, improved safety and fewer spills".

Most of the technologies that becomes diffused are related to challenges in fields at the NCS, and are the same challenges that triggered the innovative process in the first place; efficiency, cost reduction, IOR/EOR, high pressure, etc. Petroleum companies that operates at the NCS are very rational in their decisions and choices and is seen as quite conservative, thus when there are several solutions to one challenge petroleum companies tend to choose the cheapest solution (Inge Carlsen, 2011). The authorities can ask for assessments if they suspect inappropriate operations, but they will only take direct actions in situations where there is obvious waste of resources. This is very demanding because of high complexity and many parts (Bente Nyland, 2011). According to Runar Rugtvedt (2011) it is very good that the BAT arrangement is written down in the framework, as he explains; "In some fields where the profit margin is not the best there are examples where BAT is not used because of cost and price issues. So it is good for Norway to have this option to make sure that not too discarded technology is used". This means that in situations where petroleum companies' make use of cheap components which might create dangerous situations or impact the total potential of the

[41] http://www.regjeringen.no/nb/dep/md/dok/rapporter_planer/rapporter/2007/naringslivets-miljoansvar/-5/-3/-2.html?id=477932

reservoir due to bad quality; the authorities can use the BAT agreement and request that the petroleum companies choose a different technological solution that is more optimal.

4.9 Summary Empirical Data

Through an innovative process stakeholders are developing technology at the NCS. The main stakeholders of technology development at the NCS have been presented; with their role, function, and contribution to the development process. The authority's main framework for the petroleum industry has been described and we have seen that there seems to be a healthy environment for innovative efforts to take place in Norway. Petroleum companies' challenges trigger a need for technology to be developed, and petroleum companies also decide which technologies that are successfully adopted and diffused. Qualification of technology is very important in Norway follows, and can be considered its own phase in technology development at the NCS. Data collected in this study suggests that qualification is slowed down and increased investment to qualification/demonstration efforts is requested. In the end of this chapter we have seen that the Norwegian authorities do not have specific requirement to which technologies to utilize or develop, but rather places the responsibility, to choose appropriate technologies, onto the petroleum companies. Petroleum companies tend to chose technologies that are saving costs and increasing efficiency.

5. Analysis

5.1 The Institutionalized Framework

In the Norwegian petroleum industry there are a few major factors that are part of setting the framework for the petroleum industry and technology development, the authority's regulations, the market itself, and matters related to education. The theory of institutional isomorphism is about how and why organizations within the same organizational field change in formal structure, organizational culture, goals, program, without becoming more effective. Most organizations do not seek changes that doesn't improve their business in some way, thus such changes are often related to external pressure and forced changes. The term 'organizational field' relates to the NCS as stakeholders within the same stakeholder group that all belong to the same organizational field. Common for such changes is that they apply to all stakeholders and thus contributes to make the industry more uniform. It is not necessarily a bad thing that the petroleum industry is uniform if things are done correctly. Below isomorphic institutionalization found in the empirical data-set are presented.

5.1.1 Coercive

Because of the values involved and the strategic importance of energy, the petroleum industry in Norway is highly structured by the authority's comprehensive and precautionary framework; in form of laws, regulations, strategies, and other contstraits and provisions that the industry have to comply with. It is only natural that a host country use these measures to protect their rights and their environment and it is in this way Norway makes sure that their standards are utilized in petroleum operations on Norwegian soil, and that they receive value for their resources. This is examples of coercive isomorphism where the stakeholders at the NCS have to adapt and adjust the authorities demands to be allowed access to the NCS. Together with the infrastructure (research & educational facilities, testing facilities, programs, other regulated industries, governmentally owned agencies, etc.) the provisions can be viewed upon as an institutionalized framework that has been developed over the years. Too stringent regulations can lead to too much homogenity amongst stakeholders and can prevent innovativeness. The reason for this is that similar organizations think and act alike which can lead to insufficient pionering and fresh ideas, further too much regulation can result in international companies moving their research & development efforts away from Norway to another country with less regulations. It does however seems like Norway have found the right balance between their regulations and BAT/functional demands that allows the petroleum industry to operate in a way they find acceptable and profitable. The result is that Norway is a technology hub and many big international petroleum companies and contractors have made sure that they have a strong research & development unit present in Norway because of the innovative environment there. Examples of a pioneering technology that is being developed is the extremely costy pilot projects on subsea compression being qualified for Åsgard and Ormen Lange, - where the upside is so big that the petroleum companies are willing to participate in hugly costly and risky projects. The reason that makes petroleum companies able to take such risks is that the authorities have incorporated incentives for innovative efforts into its regulations; through its taxation system, financial agreements, research programs, and tax scheme agreement for innovation, etc. Another reason is that functional demands provide freedom to operators at the NCS and works as counterbalance to many other provisions. The authorities have further shown ability and willingness to adjust to changing conditions when they saw a need for smaller companies that could handle smaller or matured/abandoned fields, they made arrangements so that these companies were able to enter the NCS on more competitive terms. Previously only large companies with economic of scale were allowed/able to operate in Norway, but the authorities facilitating effort for smaller companies have worked against too much homogeneity at the NCS in that a much wider variety of companies are involved in the industry now.

5.1.2 Mimetic

In the petroleum industry and especially in harsh operational areas, uncertainty is an everyday presence that is difficult to avoid. Uncertainty can be related to almost everything in a technology development project at the NCS; weather, time, funding, costs, security, technology, etc. According to the theory a way to reduce and avoid uncertainty is by benchmarking routines, technology, processes, etc, that other have adopted and are using with good results. This is a form of mimetic isomorphism that is usual in most industries and especially in industries with a high level of uncertainty, like the petroleum industry in Norway. One can say that this is an institutionalized process/action that is used by stakeholders at the NCS when uncertainty is high. Benchmarking will save costs related to research & development and solutions that have demonstrated capability will dramatically reduce uncertainty, but at the same time it will contribute to more similarity in that they are using same technologies/procedures/standards. North Energy confirmed that they are benchmarking technology rather than developing their own, while Statoil on the other hand do own research but for the most part hire others to do the necessary technology development. Mimetic isomorphism is thus very much present at the NCS in that stakeholders benchmark each other's technologies and standards that have already proven its quality through usage. Big petroleum companies with operating rights on big petroleum fields are in a position where they can develop new solutions, while smaller companies are more inclined to benchmarking. In most cases however it is more appropriate to benchmark someone else's solution rather than spending money rediscovering the wheel.

5.1.3 Normative

Highly structured industries will normally have quite uniform institutionalized stakeholders because of many regulations and limitations, and this is also true for the NCS as we have already seen. Another reason for uniformity of the industry is that inside each stakeholder company that operates at the NCS there are employees and specialized personnel that have similar education, experiences, and that attend the same networks, workshops, etc. It is therefore reasonable to assume that they tend to think and act similar. This is a form of normative isomorphism which also causes stakeholders at the NCS to become similar to each other. The companies at the NCS chose from the same population of applicants when they hire employees, and thus there is little difference between how managers and specialized personnel solve tasks in each their organizations, adjusted for small discrepancies of personality and chance. Normative change at the NCS is by the author considered to constitute a small but inevitable factor as a result of the educational system, and it's not necessarily negative that "everybody" is solving similar problems in a uniform way on the contrary it may be an advantage if the execution is correct. And the empirical chapter provided information suggesting that execution at the NCS is very good.

5.2 Stakeholder Relations

As mentioned in the theoretical chapter the basic idea of stakeholder theory is that organizations that want to be successful and achieve their goals (create value to investors) need to know all their stakeholders and these stakeholders relationship and interest to their business. At the NCS the organizational field involves all actors who in some aspect are connected to the industry, being contractors, suppliers, electricians, government, national oil companies, international oil companies, fishermen, etc. The empirical data show that the stakeholder of the Norwegian petroleum industry, and thus stakeholders of the technology development processes, seems to be very aware of each other's presence, what they do, and how this can impact their own corporation. Both petroleum companies and contractors make use of universities and research institutes for basic research, and as long as the necessary knowledge is there both Statoil and North Energy use local forces to the full extent and in that way part of making ripple-effects into the community. The Norwegian petroleum industry is of such a character that it often requires cooperation in huge operations to make the resources available in a way that is commercial viable. The harsh conditions have stimulated cooperation and the authorities facilitate for increased cooperation through the FORCE initiative, DEMO2000 and other schemes. For small and medium sized companies the cooperation through JIP's are very important to make them compatible, but even big petroleum countries depends on cooperation with other stakeholders. Extensive cooperation has resulted in technology-clusters that are doing exceptionally well both domestically and internationally. One such cluster is the drilling-cluster in the south with EMC Node as an umbrella organization which holds around fifty drilling related companies. Other clusters are subsea, seismic, and maritime vessels where Norwegian contractors have world class products and services to offer. Thus the empirical data indicates a high level of cooperation and communication amongst stakeholders of the NCS when it comes to technology development, and that they utilize each other's expertise often.

Both the authorities and the community observe petroleum companies and partners in their operations and will try to influence them if they can. The community as a stakeholder is different from the rest in that they do not participate in the innovative process but actively work to make their opinions taken into consideration, and is thus standing on the outside with few and weak measures to influence an innovative development process. The community can also actively promote alternative technology components that are less harmful to the environment, and according to Gøril Tjetland (2011) there is a lot of developed technology that could ease the impact the petroleum industry has on the environment. The technology is qualified and ready to use but no one is interested in adopting and implementing these innovations because economically there is no obvious reason to do so. The reason for this is that petroleum companies already have good working technology, and do not see any reason to change it with something that is only equally good in performance. The community influence alone rarely lead to decision being altered by petroleum companies or other stakeholders, but they often put focus on issues that often becomes attention of the media and politicians.

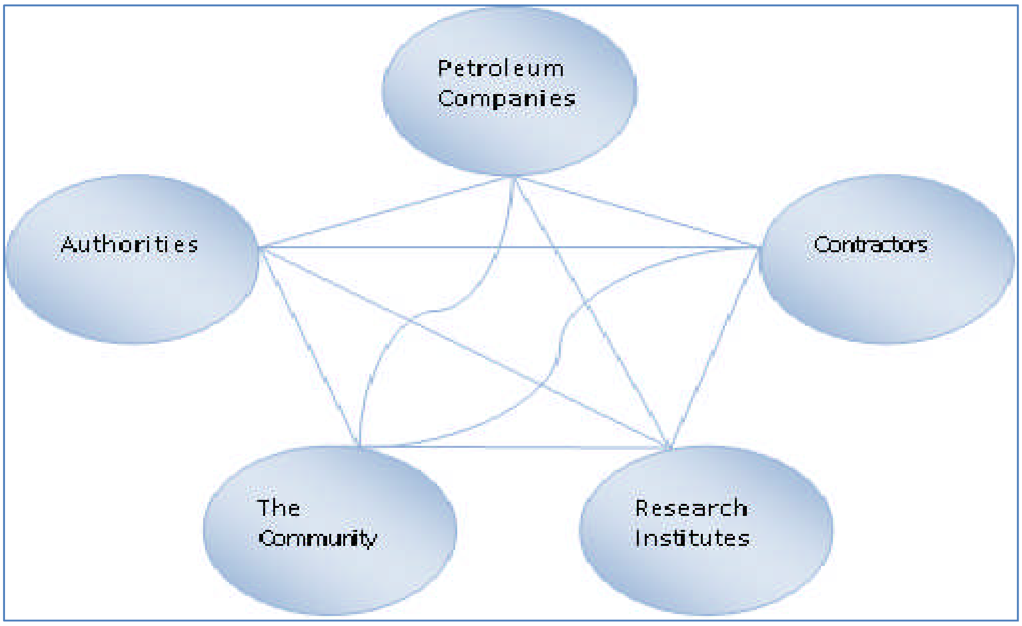


Figure 22 Stakeholder Relations at NCS

In figure 22 I have illustrate that the empirical data shows that the different stakeholders are aware of each other, that they have established contact with each other, and are oriented towards communication and cooperation. The lines running from the community to the petroleum companies and contractors are twisted to illustrate that it is difficult for the community to get their voice heard and be taken into consideration by the industry. However recent big petroleum related accidents have started to turn the focus from cutting costs and time, to more attention on HSE and increasing climate considerations. According to Inge Carlsen (2011) this is a permanent change in the industry where petroleum companies now have changed scorecards and how they assess value. With this change the community as a stakeholder are becoming more easily heard than before but they have not acquired more influence over innovative projects. In Norway the debate of petroleum activity at Lofoten/Vesterålen shelf have shown proof of this as the community managed to have their opinion taken into account, but only temporarily. They may not be equally successful in the future, as the Deep Horizon accident happened during this period and the public panic after the accident was high. But Petroleum companies learned from the accident that such huge accidents bring with them negative consequences in form of high clean-up costs, other aftermath costs, reduced reputation, halt in production, etc. I believe that it is not so much the pressure from the community stakeholder that have changed the petroleum companies way of assessing value, rather it is petroleum companies that are turning away from risks. As the world in general is becoming more concerned with climate change it has become more important to petroleum companies to demonstrate corporate responsibility to have a good reputation in the public eye, and because they are measured by it as it has become a competitive edge when it comes to winning licenses and tenders. Another ‘new’ environmental risk is connected to the fact that the most easily accessible petroleum is already found and thus new fields are often located in more challenging areas, with deep water (Deep Horizon), higher pressure, higher temperature, near foreshore, drift ice, super cooled water, etc. Common for both the ‘new’ environmental risks is that petroleum companies have to use more time planning and surveying before they can start operations or make big decisions; to make sure all possible precautions against potential accidents have been made. These ‘climate adoptions’ can potentially decrease petroleum companies’ profit and thus less will be used on technology development, further it will have negative consequences on the technology development timeline because it will take more time planning and surveying before a development process can start.

5.3 The Institutionalized Technology Development Process at the NCS

Analysis of the empirical data shows that technology developments at the NCS follows the same phases as the innovative theory displayed in chapter two, but with an additional phase. The additional phase is the qualification/demonstration of technology that is an important and inevitable phase in the petroleum industry in Norway, and a phase that is critical to if the product of the development process becomes adopted/diffused and institutionalized. Qualification of technology is taking place after the development phase and before the commercialization phase. Some would argue that qualification could be included in the development stage, but the qualification efforts are so extensive and vital that it is rewarded with its own stage. The figure below illustrates how the institutionalized process of technology development is carried out at the NCS.

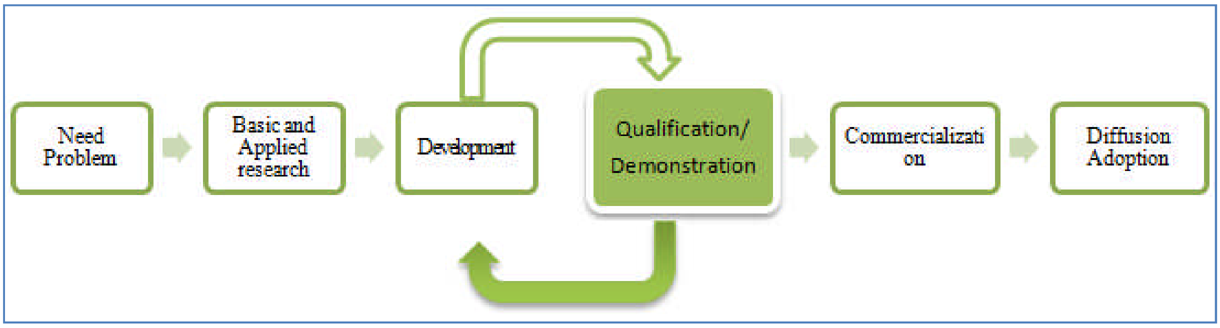


Figure 23 the Institutionalized Process of Technology Development at the NCS

The figure also illustrates that after development of a technological product, qualification testing will most often bring forward needs for adjustments or improvements. As a result further development of the product is necessary before it is able to pass through the qualification stage, thus the arrows back and forth between these two phases. The technology development process that is utilized at the NCS is very similar to that of the innovative theory; the reason is that the innovative process is a paradigm that has accumulated supporters and data that confirms the model over the years. As a result over time it has become a standard procedure for developing a product as people has found this to be most effective, and that if you omit one of the stages it may affect the end-result. Thus it has become the standard solution for developing a product, and therefore it is an institutionalized process. The normal progression that technology development at the NCS follows is hence very much an institutionalized process. This is why the innovative theory was chosen in the first place, because I assumed that it was applicable to Norway, and thus it was used as my starting point when I wanted to explore technology development. Technology development as an institutional process at the NCS can be shortened into the following three stages that I have named:

- Product Development
- Product Qualification
- Product Institutionalization

5.3.1 Product Development

At the NCS petroleum companies play the lead role when it comes to starting technology development since their challenges are dictating which efforts that are prioritized by all stakeholders, except the authorities. The challenges in Norway are triggering technology demands because it is jamming petroleum companies' operations in some fashion. In turn this will start an innovative project that aims to solve the problem. At the NCS such technology driven challenges can be divided into five groups:

- Acquiring licenses/tenders (showing capabilities)
- Harsh conditions (high costs, geology, pressure, temperature, depth, etc)
- Tail production (low pressure in reservoir requires etc. IOR/EOR)
- New discoveries (exploration technology, programs and knowledge to interpret data)
- Authority demands (health, safety, environmental, and other provisions or influences)

Common for these challenges are that they are related to finding petroleum and extracting petroleum under difficult conditions; as cost and production effective as possible. The difficult conditions offshore Norway are very costly to operate under compared to other petroleum producing countries, consequently technology is important for petroleum companies to better the profit margins and become more competitive compared to the rest of the petroleum producing world. Much of the future petroleum resources are located in much harsher environments than present reserves therefore the future will be even more dependent on technology than the past.

The empirical data suggests that the research & development environment at the NCS is very good, as new and groundbreaking solutions constantly are coming from contractors here making previously inaccessible petroleum resources available. Norway has since the 70's built up a very well functioning research & development infrastructure with many highly proficient institutes on petroleum issues. Except Norwegian companies, foreign corporations are very much present and helps drive the process forward with both knowledge and huge investments. Petroleum companies have some research they prefer to do themselves while other research is preferred assigned to contractors, research institutes, and universities. Derived from the empirical data the petroleum companies are doing research & development in their own facilities in regards to especially qualification efforts, but also in relation to the secrecy of creation and interpretation of seismic data.

Though the initiative to solutions or developments to the obstructive problem can come from any of the stakeholders at the NCS, it is however a limitation that most stakeholders have small margins and the authorities and/or a big petroleum company's presence is usually required to be able to start a development project. This is especially true for research institutes and universities and can be considered a weakness but unfortunately it seems that both the authorities and petroleum companies feel that they enough basic funds to solve their missions. Additional funds can easily be provided later if they see need for it. Research institutes and universities will always be dependent on external funding, while contractors are more independent, but still dependent on autorities or a petroleum company sooner or later in the process. The latest trend is that more contractors are saving money for research & development efforst and clearly wants to rid themselves of some of this dependency of others. Big petroleum companies with lots of funding can allow themselves to use research & development as a playground where they can experiment. Smaller petroleum companies cannot do this as they have to be on the lookout for fast cash-flows so that they in turn can grow and later be able to contribute with research & development. The Authorities are facilitating and making it easier for small and medium sized companies to participate, but when it comes to development it seems that the large contractors are winning most tenders, and one can only assume that it is because they are better qualified to solve the assignment.

The authorities expect that the industry comes up with solutions to challenges, but sometimes the industry do not initiate because the economic and technical risk is too high. This is why the authorities are always looking at issues that are socioeconomic valuable in the long run, and that is not initiated by the industry on its own. Many of these issues are covered by the authority's programs and through their applied pressure, which reflect the long term petroleum technology strategy OG21. Thus in the Norwegian petroleum industry there exists a mission allocation when it comes to research, development, and innovativeness that ensures that all important aspects and issues are considered and dealt with. The division of responsibility has come natural since petroleum companies (and the industry in general) are mostly concerned with short-term challenges in specific fields, and vigilant Norwegian authorities are picking up the loose ends and takes responsibility for long-term issues. This is according to their long-term strategy and assures good interaction between the authorities, research institutes, universities, and the petroleum industry. They leave nothing to up to chance, rather deal with all possibilities as soon as possible.

In relation to the first bull-point above (acquiring licenses) some respondents mentioned that competition can sometimes ruin an open technology arena in relation to the exploration phase. In the exploration stage petroleum companies and contractors compete with their colleagues within each their stakeholder group for respectively licences and tenders. This completion gives the stakeholders incentives to be better than their competitors in terms of capabilities and technologies. At the NCS this has lead to an ‘arms race’ of knowledge and innovations since it enhances capabilities and the probability of winning contracts on the most promising licenses. The technology related to exploration of petroleum is known, but the competition is related to knowledge, i.e. programming, interpretation of data, analyzing results, etc, and thus initially a competition for the best human resources. In the phases of production and field development there is little competition and they can only do their best while monitoring their competitors closely and perhaps benchmark competitors if they have better solutions. The conclusion is therefore that in both instances the rivalry is mainly between actors within the same stakeholder groups and can only be viewed upon as healthy competition. However if secrecy becomes too big it could reduce and weaken small and medium sized stakeholders’ ability to participate as they would potentially be shielded-off technology important and necessary to operate at the NCS.

5.3.2 Product Qualification

After a prototype is developed intensive and realistic testing is carried out, sometimes together with other components, in accordance with petroleum companies’ specifications. Only when the petroleum company is a hundred percent sure that the innovation will function well under the right conditions will they approve the innovation and end the qualification stage. Not all developments manage to become commercially successful and qualified technology will be much easier to commercialize and sell compared to un-tested technologies, since they hold promise of high quality. The buyer feel reassured knowing this which in turn makes their decision-making efforts less, and qualification of technology is therefore very important for the diffusion of the developed product. Qualification of technology happens for the most part at facilities in operation and thus all developers are dependent on petroleum companies' willingness to let qualification processes take place at their installations. Only petroleum companies and the authorities have the economic muscles and operative production facilities needed to conduct qualification testing. From the perspective of the operator and the fields owners qualification can be a double-edged sword since on the positive side it could lead to acquiring of technologies that could improve their operations, but from the negative perspective lose income due to halt in operations. Not to mention increased risks of accidents when they have to shut down well run operations and open up an 'experiment' instead. Qualification is done in cooperation between the petroleum companies and contractors. The authorities often hear from the industry that it is challenging to qualify technology at the NCS at the moment, and that many feels that Statoil with its dominant role could have done more (Reidar Müller, 2011). In bad times like just now in Norway with just few and small discoveries (with one exception), big petroleum companies are putting off qualification projects because small reserves cannot support technology development. The authority's financial contribution to qualification to technology development is also considered to be very small compared to other initiatives. Statements in the empirical chapter indicate that there is a bottle neck in the qualification stage and that more technologies could have been qualified and made available to the market sooner. This would contribute to increase the production at the NCS faster had only the additional funding and willingness for qualification efforts been supplied from both petroleum companies and the authority. From the authorities perspective they only want to stimulate private initiative and are doing that by funding qualification efforts with just under 50 million NOK each year, which triggers private investment 3-4 times that of the authority's funding. But DEMO2000 was initially supposed to be funded with around 100 million NOK each year. In addition the OG21 strategy report, the extraction committee, and experts recommends that authority funding for demonstration of prototypes and conduction of pilot testing to be increased significantly to at least 100-150 million. With all these facts produced from within the authorities itself it is a paradox that not more funding has found its way to qualification/demonstration efforts long time ago as it seems clear that the need is there and everybody knows it.

5.4 Product Institutionalization

5.4.1 Habitualization

In the pre-institutional stage the product has been developed and is finished testing and has successfully been qualified. Habitualization is about making the product known and available. Both the process of institutionalization and the innovative theory's S-curve indicate that only a few early adopters acquire the innovation at this stage. At the NCS it is like the theory describes; at this stage adoption is mostly an independent action and adoption rates are low, often just a single petroleum company that is part owner of the developed product. The reasons for low adoption rates is that most qualified innovations are made with a specific usage or location in mind and thus not necessarily fitting other fields without adjustments that could require a new qualification round. Further many end-users cannot afford to buy new technologies or they just do not see the value in changing working components with something new. The theory also mention that adoption at this stage could be slowed down because of lack of consensus of utility of the product and internal risk aversion. Related to the NCS it can be smart to wait to adopt since there is a huge difference between testing and actual usage over several year. Adoption is also low because at the NCS some potential buyers chose to wait and gather more information so that they better can assess the utility and the risk of adopting the product. In addition one can also get information on how easy/hard the innovation is to maintenance. This is information that quickly can make a very promising technology look unattractive. If there are more than one adopter to this technology after the initial release it is most likely that they have cooperated in developing the product since they are facing the same problem. Thus even though the product is qualified there are still reservations that will contribute to low adoption rates at this stage because potential customers perceive high uncertainty related to change to something different, technologically and economically adoption can be impossible for some, and the existence of already implemented working technology. The product, how perfect it might be, will still not be the first solution potential customers think of when they contemplate on their challenge.

5.4.2 Commercialization and Objectification

In the semi-institutionalized stage of objectification the product has become fairly widely diffused and institutionalization at this level dependents on end-users common and favourable perceptions of product. At the NCS the developer (champion) will contribute to similar perceptions of an innovation through commercializing (theorizing), by highlighting the innovations benefits and results from testing and by connecting it to a specific challenge. Except from the champions theorizing, information on a product are also reaching potential customer through the first reports from early adopters, media, colleagues, networks, and other information channels. According to the institutional theory potential customers will consciously monitor the accumulation of evidence on the quality and effectiveness to use in own assessments. In innovative theory the S-curve confirms this by illustrating how adoption rates are connected with the performance of the product. Petroleum companies are known for being quite conservative in their decision-making because of high investment and risk involved and some will still want to gather own information to make sure that the product have required quality and usage. This is the case in Norway too regardless of a product has been qualified. The consequences of buying the wrong product are so big that customers want to do own evaluations. At the NCS there is little discussion concerning products functionality after such extreme testing, rather the questions potential customers are asking themselves are; is the product going to work the way we are going to use it? How long will the product last? How many times does it need maintenance during that time? Benchmarking of competitors is a strategy used by potential customers as a way of reducing uncertainty and keeping costs low by imitating and copying successful solutions. North Energy acknowledge that they are using this strategy because it saves time, costs, and keeps risks lower than if they were to develop something of their own, while Statoil stimulates innovativeness in others and then adopt qualified solutions rather than undertake huge developments on their own. Both cases are efforts made to avoid and share the risk with others. In Norway when a solution has proven that it works offshore news of its excellence will travel fast and potential customers with similar challenges will show their interest. In contrast to the previous phase uncertainty to change to the product is much less and contributes to higher adoption rates because reports from early adopters and subsequent benchmarking of others that have already implemented the product with success. The high quality standards that are used in Norway and the fact that developers there are concerned with protecting their patented rights and continuously improving their products are all contributing to increasing adoption rates. In addition the Norwegian authorities have also made a target in their OG21 strategy to increase export of technology, and developers at the NCS are indeed exporting technology and wanting to export more. While technological and economical viability is also applicable in this stage and together with thoroughly decision-making process it keeps the adoption numbers from sky-rocketing. Thus more customers are adopting the product at this point due to; high quality, commercialization efforts, and benchmarking, which all contributes to increasing the adoption rate and the level of institutionalization.

5.4.3 Fully Diffused and Institutionalized

In the last stage of sedimentation, fully institutionalization depends on continuity of the established structure amongst end-users. This means that the product have to be adopted by the majority of potential customers and that they utilize the product over a longer period of time. Both the innovative theory and institutional theory points to the necessity of continuous usage over a longer period in time. Opposed to the two previous stages; petroleum companies' conservative decision-making will at this stage help maintain cultural support and promotion of the product that is now fully institutionalized. At the NCS operators are very careful to make changes because of the high cost/risks involved and therefore they tend to hold on to what works rather than implementing new solutions, unless the new innovation can save costs or increase efficiency. At the NCS qualified, commercialized, and widely diffused technology holds promise of such high quality that stakeholders will at this point have no reservations weather to adopt or not. Some late adopters are at this stage joining in as the adoption rate is about to flatten out and the only thing that could stop someone from implementing the solution is what is technical and economical viable for the organization. The theory mention that it is important for continuity to have interest group advocacy to resist 'negative' interest groups, and the petroleum industry is especially exposed to 'negative' interest groups that in some extreme cases can influence petroleum companies operations. Developers at the NCS have their seller teams and information consultants that maintain the products reputation, and it's important that these people are aware of the public opinion in relation to their business. At the NCS there have been some opposition but the petroleum industry have stepped forward with cautiousness and shown etiquette. Most technological developments that are coming out of the NCS are applauded and are virtually selling themselves. The institutional theory also mentions that lack of demonstrable results could hinder institutionalization, and this is further backed by the S-curve in innovative theory. In the context of technology development at the NCS it would equal a situation where the innovation is not delivering results as those accomplished during the qualification. This study have not found indications that it is something that occurs in Norway today and if such a situation would occur it is likely that it would happen at an earlier stage, and at the latest during the qualification process. In the offshore petroleum industry such an outcome is catastrophic with huge sunk costs and this is why testing and re-testing during the qualification phase is very important to petroleum companies operating at the NCS.

5.5 Summary Analysis

In this chapter I have highlighted important aspects within utilized theories and analysed the empirical data and drawn parallels to the petroleum industry in Norway. First we have seen how institutional isomorphism is present at the NCS and making stakeholders more similar to each other and together with stakeholder relations it is viewed as part of the petroleum industry framework. The institutionalized technology development process with its different stages has been explored and important aspects have been highlighted and factors that can slow down the process indicated. In the end important aspects from the institutional process have been discussed in relations to the petroleum industry in Norway.

6. Conclusion

This thesis has explored the institutionalized process of technology development at the NCS by looking at the; external framework that surrounds the process, stakeholders of the process, the stages in the process. The goal has been to identify factors that contribute to slow down the technology development process. In this chapter I will therefore try to sum up and conclude on the situation around the technology development process at the NCS.

6.1 The Institutional framework/Stakeholder Relations

As a host-government controlling valuable natural resources Norway has rigorous regulations and high taxes, but has also implemented incentives for research and development in the framework. Strict regulations are nicely balanced with functional demands in relations to how to operate, and the BAT arrangement in relation to which technology to use in operations. Petroleum companies are virtually free to use the solution they want in operations, but at the same time they alone carry the responsibility for potential accidents. In Norway this solution is working well but there have been some issues related to safety, but not outdated technology. Norway seems to have found a balance that is close to an ideal research & development environment, and with strategies and long-term perspective. OG21 strategy and other governmental documents related to petroleum research are ensuring a coordinated effort between universities, research institutes and the petroleum industry. These stakeholder use each other's expertise and cooperate when necessary, behaviour which has resulted in a large and open innovative environment. The only thing in the framework that potentially is slowing down the technology development at the NCS is the funding (highlighted soon) and the 'new' environmental risks that forces developers to make economical unfavourable preliminary studies, beyond those that is already required.

6.2 The Institutional technology process

The challenges related to extracting petroleum are creating demand for technology development efforts and therefore it is challenges belonging to petroleum companies. The efforts to solve the challenge are done in cooperation between petroleum companies and stakeholder resources that are present at the NCS and on the main land. Except from the petroleum companies, the authority, and some few large contractors most stakeholders have limited funds and few means to start something on their own. If a stakeholder is lucky they might get stimulation from the industry or through authority programs in an area where they have expertise. Otherwise the empirical data indicate that financially weak stakeholder find the funding of independent research & development to be insufficient, while the financially strong stakeholders seems to think the amounts to independent research are suitable. It can be bad for generation of new ideas that potential developers are not allowed to do more independent research & development and it can be an idea to increase the funding. Never the less all stakeholders have possibilities to be part of petroleum technology development.

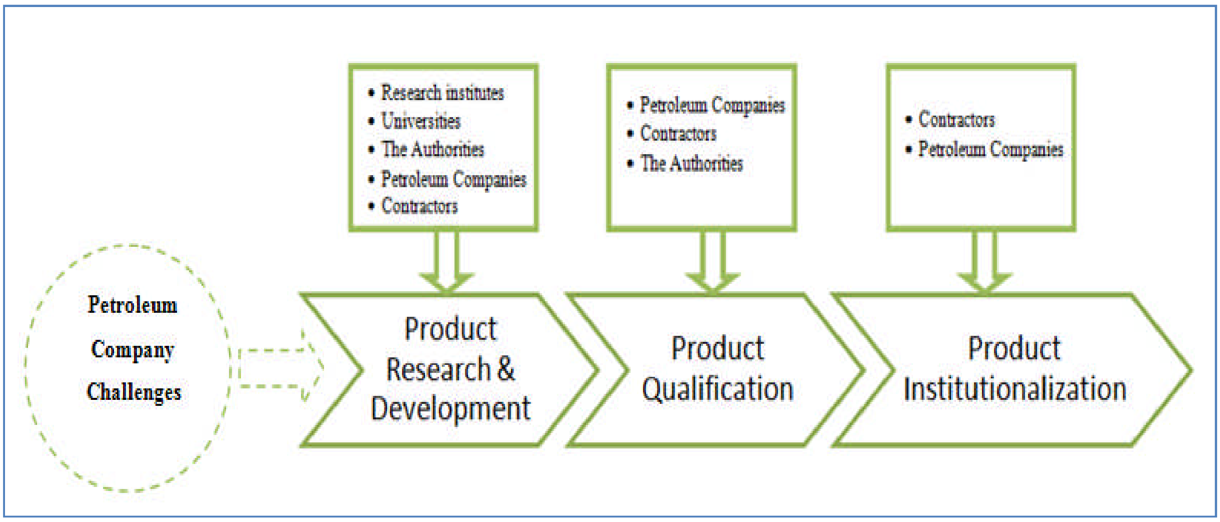


Figure 24 the Institutional Technology Development Process at the NCS

The figure illustrates the technology development process at the NCS with the extraction challenges leading up to the process. Above each stage a boxes with stakeholder names is placed, illustrating participants in each stage. Together with contractors' the petroleum companies are doing most of the applied research, while research institutes, universities, and to some extent contractors, are doing the basic research. It seems appropriate that petroleum companies and contractors are doing most of the applied research concerning details since they are part of developing the product together, while the research institutes and universities, with the authorities in front, are responsible for the more important and time-consuming effort to overview environment and the bigger details. After research is done the rest of the stages are mainly done by the petroleum company and the contractor. In the qualification stage it is the contractors that develops the product but according to petroleum companies' specifications in terms of quality and functionality. This is a two-way interaction with the contractors at the wheel in this phase as they 'steer' the progression, and the petroleum companies monitoring every step to make sure that it is done according to specifications.

The product qualification is the bottleneck in the technology development process at the NCS, and only the petroleum companies and authority have the financial ability to do something about the situation. After 10-15 years with few and small discoveries petroleum companies have lost their willingness to participate in piloting projects because small findings cannot support development. This has put the responsibility on contractors that which has made them prioritize petroleum matters less. In such down periods perhaps the authorities could have increase and spur more efforts, and maybe Statoil could have shown more long-term thinking and willingness to keep the process run more smoothly all the time independently of 'seasonal variations'. Authority appointed committees and other sources confirms that need for more funding for qualification of technology is there, so it is a paradox that there haven't been bigger increases in qualification efforts already. The only explanation can be that there is a lack of willingness from both petroleum companies and the authority since everybody seems to acknowledge the need.

Related to the NCS, characteristics of the product institutionalization process are after the release of the product that the adoption rates are low, and if more than one petroleum company adopts the product it is more than likely that they have cooperated in the developing. There seems to be three reasons to why there is low adoption rates at this point; first existing already implemented technology, second because of uncertainty and technical & economical viability, third it can be smart to wait for several reasons and gather more information before implementing. In the mid-product institutionalization when the product has been utilized by early adopters for some time, the diffusion accelerates both because of information from the developer but also from own surveys. Information on new available solutions travels fast at the NCS and no one is holding back technology, but still what is technical and economical viable is slowing down implementation. In this last stage of product institutionalization petroleum companies' conservative decision-making contributes to maintain continued usage of a product that is already commercially successful and fully institutionalized. Petroleum companies do not change something that works unless it can save costs or increase efficiency.

As a conclusion of it all I would say that this study has revealed mostly positive things related to the technology development at the NCS. It is a great environment for innovativeness but there are issues slowing down the process but not more than that successful technology is produced from there. Just maybe not as much development as one could hope for since production and reserves have declined and harsher and more unavailable conditions are waiting in the future. In Norway it takes a long time between when ideas come to mind and the product is created, and long time between investments are made in new technology developments or qualification projects. Successful technology development has materialized in skilful clusters but still the technology development is not running at full speed. Technology development is an area of possibility and growth for a country like Norway, and Norway has a comparative advantage in offshore petroleum operations. Thus the conclusion is that most things are going well, but the qualification and implementation of technology is slowing down the development process, and more funding could and should be injected into petroleum research and development efforts.

7. List of References:

7.1 Books

Bell, E., and Bryman, A. 2007. Business Research Methods. Oxford University Press.

Berg, B. L. 2009. Qualitative Research Methods – For the Social Sciences. Allyn & Bacon, London.

Denzin, N. K., and Lincoln, Y. S. 1998. The Landscape of Qualitative Research – Theories and Issues. SAGE Publications, Inc. Thousand Oaks, California.

Easterby-Smith, M., Jackson, P. R., and Thorpe, R. 2008. Management Research. SAGE Publications Ltd. London.

Freeman, E.R., Harrison, J.S., and Wicks, A.C. 2007. Managing for Stakeholders: Survival, Reputation, and Success. Yale University Press. New Haven & London.

Hurst, D., and Viber, C. 2004. Theories of macro-organizational behaviour: a handbook of ideas and explanations. M.E. Sharp, Inc.

Sellerberg, A-M. 1994. A Blend of Contradictions: Georg Simmel in Theory and Practice. Transaction Publishers. New Brunswick. N.J., U.S.A.

Ringdal, K. 2007. Enhet og Mangfold; Samfunnsvitenskapelig forskning og kvantitativ metode. Fagbokforlaget Vigmostad og Bjørke AS.

Rogers, Everett M. 2003. Diffusion of Innovations. The Free Press. New York.

Rogers, Everett M. 1995. Diffusion of Innovations. The Free Press. New York.

Ruan, J.M. 2005. Essentials of Research Methods: A guide to Social Science Research. Blackwell Publishing, Oxford, U.K.

7.2 Articles

DiMaggio. P. 1988. "Interest and Agency in Institutional Theory." In Lynne G. Zucker (ed.), Institutional Patterns and Organizations: Culture and Environment: 3-22. Cambridge, MA: Ballinger.

DiMaggio, P., & Powell, W. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields". American Sociological Review vol. 20: 147-160.

Donaldson, T., & L. Preston. 1995. "The Stakeholder Theory of the Corporation: Concepts, Evidence and Implications." Academy of Management Review vol. 20, no. 1: 65-91.

Freeman, Edward, R. & Reed, David, L. 1983. "Stockholders and Stakeholders: A New Perspective on Corporate Governance". California Management Review vol. 25, no. 3: 88-106.

Gueterbock, R. (2004) Greenpeace Campaign Case Study-Stop Esso. Journal of Consumer Behaviour, 3:3 265-271.

Isaksen, Arne. 1999. Regionale innovasjonssystemer – Innovasjon og læring i 10 regionale næringsmiljøer. R-02 av STEP-gruppen for Norges forskningsråd, Oslo.

Tolbert, S.P., and Zucker, G.L. 1996. The Institutionalization of Institutional Theory. In: Clegg, S., Hardy, C., and Walter, R.N. 1996. Handbook of Organization Studies. London and Thousand Oaks: Sage Publications: 175-190.

7.3 Reports and Documents

The Norwegian Ministry of Finance, St.meld. nr. 2 (1998/1999): The revised national budget 1999

Oil and Gas in the 21st century strategy document, 2001. Norway's Technology Strategy for the 21st century

Norwegian Academy of Technological Sciences and Offshore Media Group, 2005: Petroleum Research Pays Off

Tor Borgar Hansen, Tore Karlsson and Helge Godø, NIFU STEP, rapport nr. 7, 2005. Evaluation of the DEMO 2000 program

The Norwegian Ministry of the Environment, St.meld. nr. 8 (2005/2006): Integrated management of the marine environment in the Barents Sea and the waters off Lofoten (management plan)

David Johnston, Daniel Johnston and Tony Rogers, 2008. International Petroleum Taxation – for the independent petroleum association of America. IPAA, America's Oil & Gas Producers

Harald Tønnesen in the Norwegian Petroleum Museum yearbook, 2008. Development at the Norwegian Continental Shelf – Political constraints and technological choices

The Norwegian Petroleum Directorate commissioned by The Norwegian Ministry of Petroleum and Energy: Petroleum resources in the waters outside Lofoten, Vesterålen and Senja, 2010

North Energy annual report 2010

The Norwegian Ministry of Petroleum and Energy with the Norwegian Petroleum Directorate: Facts 2010 – Norwegian petroleum operations

The Norwegian Ministry of Petroleum and Energy, report from the Extraction Committee, 2010: Increased production on the Norwegian continental shelf

The Ministry of Petroleum and Energy and the Ministry of Labour, 2010: Guidelines for plans for development and operations of a petroleum deposit and plans for installation and operation of a petroleum deposit (PDOs) and plans for installation and operation of facilities for transport and utilisation of petroleum (PIOs)

The Norwegian Ministry of the Environment, Meld. St. nr. 10 (2010/2011): Update of the management plan for the marine environment in the Barents Sea and the waters off Lofoten

The Norwegian Ministry of Petroleum and Energy, Meld. St. nr. 28 (2010/2011): An industry for the future – Norway's petroleum activities

The Norwegian Oil Industry Association: Economic report 2011 – Optimism in the Norwegian petroleum industry-but a darker outlook for the world economy

Petoro Annual Report, 2011 – Petoro's Management and Control

The Norwegian Ministry of Petroleum and Energy with the Norwegian Petroleum Directorate: Facts 2012 –Norwegian petroleum operations

7.4 Internet (Lecture notes)

Cato Willie, 2011. As cited by Jan Terje Henriksen in Norwegian Perspectives' Lecture: Technology Development on the Norwegian Continental Shelf.

Central Bureau of Statistics. Petroleum Production First Half 2011. Downloaded February 4, 2011: http://www.ssb.no/ogprodre/

Open Innovation perspectives - the development of the Norwegian Continental Shelf. Steinkjer. 18.9.2009. Cato Willie, Chief Researcher, Ideas and Innovation Management, StatoilHydro ASA. Downloaded August 16, 2011: http://www.innovasjon.eventweb.no

8. Appendix

Appendix 1: Interview guide (Tentative)

Innovasjonsprosessen

1. Hvordan håndteres innovasjonsprosessen og hvilke faser består den av?
2. Hva utløser prosessen?
3. Hvordan stimuleres oppgavene; kommersialisering og spredning av teknologi?
4. Vanlige problemer/løsninger knyttet til prosessen?

Teknologiutviklingens aktører

1. Hvordan fungerer samarbeidet? (Stat, utdanningsinstitusjoner, forskning, industri)
2. Er det aktører som ikke deltar optimalt?
3. Hvordan får dere kjennskap til nye teknologiske innovasjoner?
    - Hvordan spres slike nyheter mellom aktørene i industrien?
    - Er det vilje til å dele på ny teknologi vs. konkurransefortrinn?
4. Hvilket eksternt press, og fra hvilke aktører, kan påvirke hvordan valg dere gjør?

Teknologivalg (Institutionalization)

1. Hvilke begrensninger eksisterer i forhold til hvilken teknologi man kan ta i bruk på norsk sokkel i forbindelse med leting/produksjon av olje og gass?
    - Søknadsprosess, faser, godkjenning eller lignende?
2. Hva er avgjørende for hvilke teknologiske løsninger som implementeres på norsk sokkel?
    - Hva er avgjørende faktorer for at en teknologisk løsning forkastes/utgår
    - Er det aktører som er avgjørende for hvilken teknologi som implementeres?
    - Hvorfor velges en løsning, mens alternativet blir forkastet?
3. Hvilke teknologiske innovasjoner har de siste årene 'slått gjennom' og blitt tatt i bruk av majoriteten på norsk sokkel? (kategorier)

Stakeholders

1. Hvordan har utviklingen endret måten vi må ta hensyn til stakeholders på?
2. Hvilke betydning har dette "ekstra" hensynet fått å si for teknologiutviklingen?
3. North Energy undersøker muligheten for et tunnelkonsept i forhold til utvinning av olje og gass i kystnære områder,
    - Hva er deres syn på en slik løsning?
    - Kan tunell konseptet være med på å løse utfordringer tatt opp i debatten om oljeutvinning i Lofoten/Vesterålen området?

Appendix 2: Authority Funding of Petroleum Research & Development

Fra: **Espen Forsberg Holmstrøm** <efh@forskningsradet.no>
Dato: 11:56 25. august 2011
Emne: VS: Tall for bevilgninger til petroleumsforskning
Til: stenna@gmail.com
Kopi: Siri Helle Friedemann <shf@forskningsradet.no>

Hei Sten-Are,

Under følger Forskningsrådets budsjettutvikling innen petroleumsforskning. Det er viktig å understreke at tallene er historisk budsjettutvikling, altså pengestrømmen inn til de forskjellige programmene fra departement/fond. Om man sammenlikner dette med tall som viser pengestrømmen ut fra Forskningsrådet, så vil det være forskjeller.

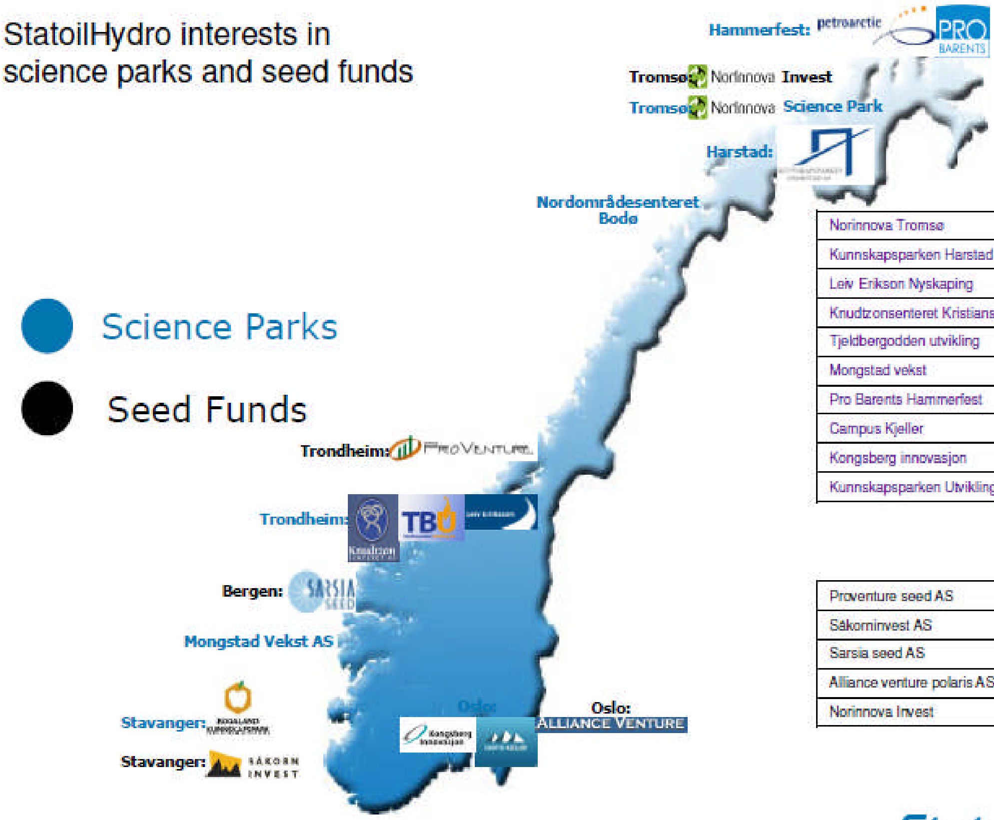
Budsjettutvikling 2002-2011	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SFF CIPR UiB (Forskningsfondet)	0,0	14,0	14,0	14,0	14,0	14,0	14,0	14	14	14
Strategisk petroleumsforkning (OED, NHD, KD)	65,9	62,6	60,1	58,9	63,1	84,4	82,6	77,9	77,9	92,9
Petromaks (OED, NHD, forskningsfondet)	0,0	0,0	55,0	162,3	236,1	228,2	223,0	181	212	207,5
Petromaks: HMS (AD)	15,0	15,0	15,0	15,0	15,5	15,4	18,9	18,8	18,8	18,8
Brukerstyrt/anvendt ekskl Petromaks (OED, NHD)	41,1	41,1	39,4	0,0	0,0	0,0				
Effekter av utslipp til sjø (OED, MD)	2,0	8,0	8,0	8,0	8,0	8,0	8,0	10,5	10,5	10,5
Demo2000 (OED)	20,0	29,0	30,0	50,0	70,0	50,0	50,0	42	48	46,7
Samfunnsfaglig petroleumsforskning (OED)	6,4	5,2	5,2	5,2	5,2	10,0	10,0	10	10	10
Demo 2000 tiltakspakke 2010									50	
Total petroleum RD&D	150,4	174,9	226,7	313,4	411,9	410	406,5	354,2	441,2	400,4

Håper det blir mulighet til å lese den delen som omhandler vår virksomhet. Lykke til med oppgaven.

Vennlig hilsen
Espen Forsberg Holmstrøm

Appendix 3: Statoil's interests in science parks and seed funds

StatoilHydro interests in science parks and seed funds



Norinnova Tromsø	10 %
Kunnskapsparken Harstad	23,8 %
Leiv Erikson Nyskaping	1,5 %
Knudtzonsenteret Kristiansund	40 %
Tjeldbergodden utvikling	40 %
Mongstad vekst	30 %
Pro Barents Hammerfest	35 %
Campus Kjeller	21,3 %
Kongsberg innovasjon	15,8 %
Kunnskapsparken Utvikling AS	26,8 %

Proventure seed AS	14,5 %
Såkorninvest AS	14,0 %
Sarsia seed AS	11,7 %
Alliance venture polaris AS	11,6 %
Norinnova Invest	15,2 %

StatoilHydro

Appendix 4: Statoil development spin-offs