NTNU – Trondheim
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Industrial Opportunities in Oil Spill Response in Norway

An Analysis of the Technological Innovation System of Oil Spill Response

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4. Bedømmelse

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Preface

Why are you interested in oil spill response? This is by far the most usual question we have received from the people we have spoken to in the course of researching and writing this thesis. The genuine surprise and joy that someone would research their specific industry was inspirational for us. The following resignation, when describing what they thought was wrong with the market and why it would continue to be so, was a further motivating factor.

In this thesis, we have researched the framework conditions of innovation in Norwegian oil spill response. The research has been based on a large pile of documents and books, and a range of interviewees from all sides of the oil spill response market. We would like to thank all 34 informants for their contributions, along with the people we met at the Interspill conference who were willing to answer our survey. We are thankful for your cooperation.

With the research and analysis accomplished in the following pages, we aim to increase the understanding of why Norwegian oil spill response is where it is today, and how it can improve for the future. In our minds, this is a task of national importance that needs more attention from the media, the public, and our elected representatives. Therefore, in an effort to raise the debate, an op-ed column on this topic has been sent to, and accepted by, the Norwegian Business Daily (DN) and will appear in June.

This master thesis is the final work of our MSc degrees with the Department of Industrial Economics and Technology Management (IØT) at the Norwegian University of Science and Technology (NTNU). We would like to thank professor Øystein Moen at IØT for his guidance through the process of writing and his comments on earlier drafts of the thesis, and the IØT faculty for withstanding us these five (six) years at Gløshaugen.

Trondheim, 08.06.12

Abstract

English / Engelsk

Recent oil spills have made headlines across the world. The 2010 blowout from the Macondo oil well flowed continuously for three months, spilling more than half a million cubic meters of oil into the Gulf of Mexico. The 2002 spill from the tanker Prestige was about a tenth in size, still contaminating thousands of kilometers of coastline. Recent Norwegian examples of spills are the Statfjord platform oil spill, and the shipwreckings of Full City and Server.

Trends in energy exploration and transport show increases both in overall activity and in activity in sensitive areas. An example is the activity on the northern coast of Russia, where oil and gas production is increasing, freight of oil is increasing, and a general transport route to Asia may be opened due to the melting of the Arctic ice cap.

Accidents and increasing activity along the Norwegian coast call for further development of the Norwegian oil spill response system and form the background for this thesis. It has investigated the conditions for innovation in the Norwegian oil spill response industry and attempted to identify how these can be strengthened. Extensive research on the workings of the system and industry has been conducted to enable a thorough analysis of the technological innovation system of oil spill response.

The analysis has resulted in two major findings. The first is the explicit definition of the market as an oligopsony. It is a market characterized by a concentration of buyer power in the two major buyers, NCA and NOFO, which in turn affects the market. One such effect is that companies in the industry are weary of expressing any criticism of the system, fearing for future sales.

The second finding is a lack of drivers of innovation in oil spill response. The incentive and opportunity to innovate has been evaluated for three groups of stakeholders: the sellers, the buyers, and the end users. The analysis shows that the sellers have neither opportunity nor incentive to invest in long-term development. The buyers—NOFO and NCA—have a varying degree of incentive to innovate, but limited opportunity. The end users have limited opportunity and incentive to innovate.

An implication of these findings is that innovation for the future Norwegian oil spill response is projected to be incremental, following the path it has trodden the last twenty years. To address this projection, and possibly shifting the path, there has been suggested certain key actions. These key actions are a start in dealing with the deficiencies that are hindering innovation in oil spill response.

Sammendrag

Norwegian / Norsk

En rekke oljesøl har i senere tid skapt overskrifter verden rundt. Macondo-utblåsningen i 2010 forårsaket et oljesøl på mer enn en halv million kubikkmeter i Mexico-gulfen. Grunnstøtingen av Prestige i 2002 medførte et søl på omtrent en tidel i størrelse av Macondo, men tilgriset likevel tusener av kilometer av kysten til Spania, Portugal og Frankrike. Norske eksempler på nyere tids oljesøl er Statfjord-utslippet, og havariene av Full City og Server.

Trender innen energiproduksjon og transport viser både en generelt økende aktivitet og en økende aktivitet i sensitive områder. Et eksempel er Russlands nordkyst, hvor olje- og gassproduksjonen tiltar, og en transportrute til Asia kan bli åpnet som følge av issmelting i Arktis.

Oljesøl og økende aktivitet langs norskekysten fører med seg et behov for videre utvikling av den norske oljevernberedskapen, og utgjør bakgrunnen for denne avhandlingen. Den har undersøkt rammebetingelsene for innovasjon i den norske oljevernindustrien, og søkt å identifisere hvordan disse kan styrkes. Omfattende undersøkelser har blitt gjennomført av hvordan oljevernsystemet og –industrien fungerer, for å muliggjøre en grundig analyse av det teknologiske innovasjonssystemet innen oljevernberedskap.

Analysen har resultert i to hovedfunn. Det første er en eksplisitt definisjon av markedet for oljevernberedskap som et oligopsoni. Det er et marked som karakteriseres av konsentrert kjøpermakt i de to store kjøperne Kystverket og NOFO. Dette har igjen effekter på markedet, og én slik effekt er at industrien er generelt forsiktig med å fremme kritikk mot systemet, i frykt for fremtidige kontrakter.

Det andre funnet er en mangel på innovasjonsdrivere innen oljevernberedskap. Incentiv og mulighet til å drive innovasjon har blitt vurdert for tre interessentgrupper: Selgerne, kjøperne og sluttbrukerne. Analysen viser at selgerne verken har incentiv eller muligheter til å investere langsiktig i nyutvikling. Kjøperne har i varierende grad incentiv, men begrensede muligheter. Sluttbrukerne har begrensninger i både incentiver og muligheter.

En implikasjon av disse funnene er at innovasjonen innen norsk oljevernberedskap er forventet å forbli inkrementell, å fortsette på den samme stien den har gått de siste 20 årene. I et forsøk på å endre retningen på utviklingen, har enkelte politikkforslag blitt inkludert. Disse forslagene er en start på en håndtering av svakheter som hindrer innovasjon i norsk oljevernberedskap.

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1 Introduction

In the 1960's and 1970's offshore oil exploitation grew to become a major part of the petroleum industry. Along with this new area of operation came new environmental challenges. One of the most hazardous of these challenges was, and still is, oil spills. Hence, alongside the development of the offshore oil industry, an oil spill response (OSR) industry has developed. This industry specializes in developing OSR technology and services in order to combat oil spills.

On the Norwegian continental shelf this is becoming an ever more important issue. Although it is sometimes claimed that Norway has the best oil spill response in the world, the need for new and better solutions is clear. There are several reasons for this:

(1) The petroleum industry is moving closer to the coast. Examples of such Norwegian offshore developments are Gjøa and most Goliat. Coastal waters are more vulnerable areas that demand stronger and quicker OSR.

(2) The petroleum industry is moving north. The activity in the Barents Sea is increasing (figure 1). Vast areas on both the Norwegian and the Russian side of the border are sparsely populated, with little infrastructure, and in general lack the capacity for large OSR operations.

Figure 1: Northern regions of Norway and Russia. Red dots (1-19) designate terminals for exporting petroleum products through the Barents Sea. Norwegian terminals are Bøkfjord (16), Sørnesfjord (17), Melkøya (18), and Goliat (19) (Bambulyak & Frantzen 2009).

(3) Transport worldwide will increase, both in freight and passenger transport. This will demand better contingency planning in general. Also, a majority of large transport vessels still run on bunker oil, a heavy residue from oil distillation used as fuel oil. This is often the main source of pollution related to ship-wreckings. Therefore, increased transport will also demand better planning of response to potential spills of fuel oil. One such example is that Russian Western Arctic ports are estimated to increase the volume of petroleum shipped from 15 to 100 million tons in the period 2009-2015.

(4) Transport in northern areas specifically will increase. The continous melting of the Arctic ice cap is opening new opportunities for transport by sea. The Northern Sea Route—along the northern coast of Russia—may become the default route from Europe to East Asia for petroleum and other goods, due to significantly shorter transport time. Weak infrastructure and response mechanisms will hence be an issue for ship transport as for the petroleum industry.

The following sub-chapters will present the problem statement of this thesis, the scope and boundaries, and explain in more detail the two major trends that call for an increased need for OSR in Norway.

1.1 Problem statement

The topic for this thesis is Norwegian oil spill response (OSR), more specifically the functioning of the OSR industry and market. The thesis will serve as a thorough analysis of Norwegian OSR from an innovation perspective. The problem statement is:

What are the industrial opportunities and challenges in the Norwegian oil spill response market? How can innovation be strengthened in this industry?

To answer these questions fully, there are several sub-questions that need to be covered:

- What is the state of this industry today in a technological and economical sense?
- Which general framework conditions apply to companies in this industry?
- How does the state of the industry and its distinct framework conditions influence innovation and development?

1.2 Scope and boundaries

There are a number of considerations to make when exploring this topic. A first consideration is what to include and what to leave out. Here, the range of applications is limited to OSR. As the

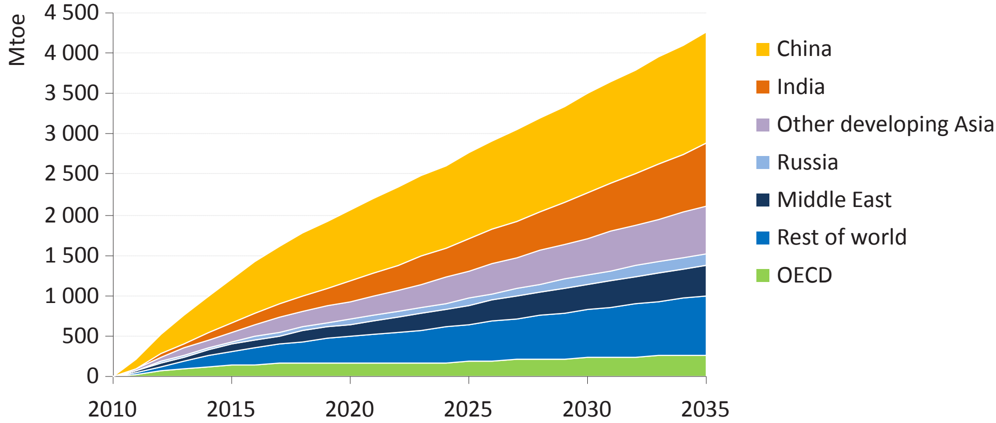


Figure 2: Growth in primary energy demand (IEA 2011b).

focus is on the OSR industry, only the production of equipment and services that is mainly OSR-related has been included. Therefore, the use of oil booms and other OSR-specific equipment is included, while general operational services such as industrial cleaning and sludge extraction is not included. The focus in the thesis is thus not on the product level but on the knowledge field of OSR products and services, specifically.

A related consideration is breadth versus depth. As the authors have not published on this topic before, it was deemed more worthwhile to focus on breadth in this thesis. The level of aggregation chosen is OSR-related products and services that are a part of the Norwegian market. The spatial domain for this thesis is limited to Norway.

1.3 Background

The challenges that increase the need for OSR in Norway are new areas of oil exploitation and increased shipping traffic along the Norwegian coastline. This chapter will give an overview of world energy and transport demand, and establish the Norwegian perspective in this context.

1.3.1 Energy: Increasing worldwide demand and consequences

From 2010 to 2035, the demand for energy will increase by one-third of today's consumption (IEA 2011a). This is estimated by World Energy Outlook, the annual report of the International Energy Agency. The uncertainty surrounding short-term economic growth has little impact on long-term energy

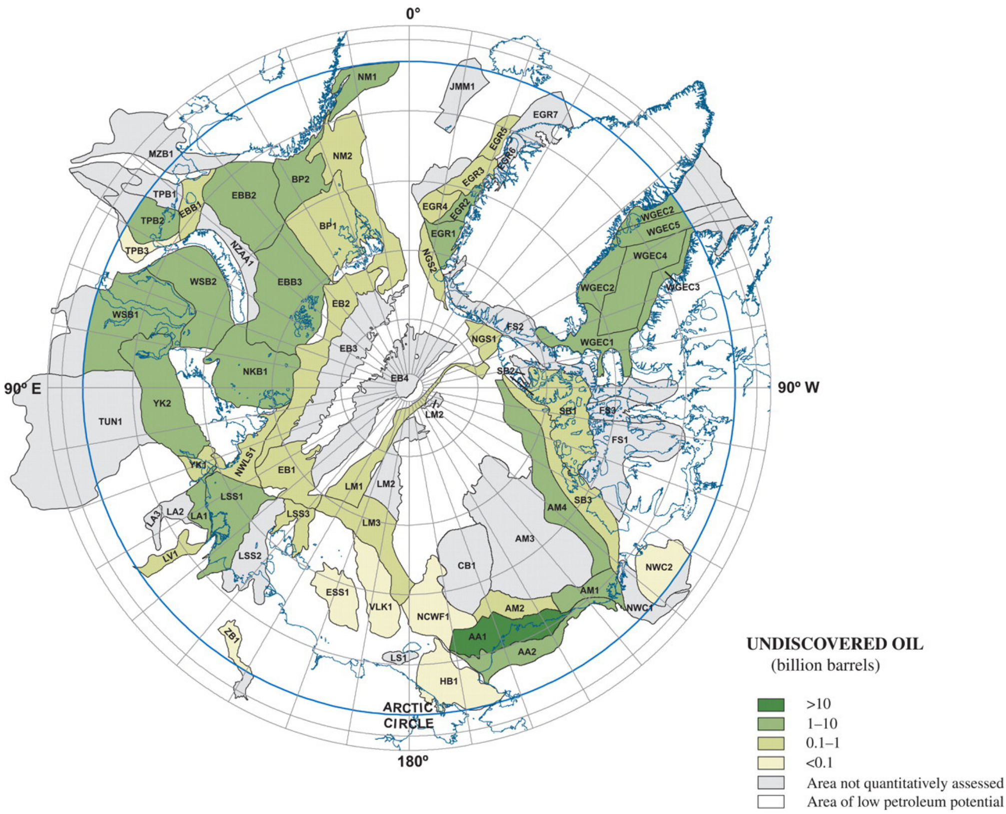


Figure 3: Estimated undiscovered gas in the High North (Gautier et al. 2009). *A similar map covering undiscovered gas in the Arctic can be found in Appendix 12.*

demand, according to the report. Of this projected increase of more than 30 per cent, China and India account for half (figure 2).

The share of fossil fuels in the global primary energy consumption declines in WEO's scenarios. This is not to say that the age of fossil fuels is over—the share is expected to fall from 81 percent to 75. The cost-to-market for oil will increase, as sources become increasingly costly, distant, and difficult to exploit. Use of coal, the fossil fuel that has met nearly half of the energy demand increase over the last decade, may with current policies rise by 65 percent by 2035. Whether this trend changes and how quickly «is among the most important questions for the future of the global energy economy» (IEA 2011b:5).

A major player in this development is Russia. According to IEA, output from oil and gas fields in Western Siberia will

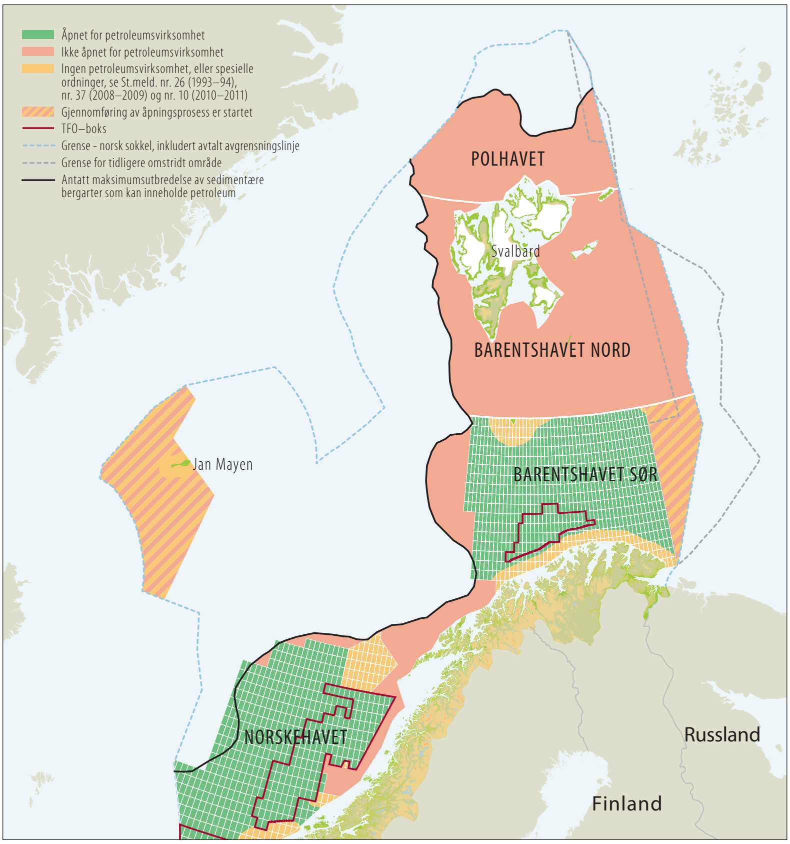


Figure 4: The northern part of the Norwegian continental shelf (OD 2011).

decline, necessitating a development of the more costly fields that are found both in Western and Eastern Siberia and in Arctic areas—the High North.

The area designated «The High North» is seen as one of the final frontiers for energy extraction. Estimates of undiscovered oil in the Arctic are shown in figure 3. The map also shows the countries directly involved in the Arctic: Russia, USA, Canada, Denmark (Greenland), Iceland, and Norway. Figure 4 shows the northern part of the Norwegian continental shelf.

In the High North, on the Norwegian side of the South Barents Sea, several new discoveries have been made. Most notable are Snøhvit, Skrugard, Goliat and most recently Havis. Figure 5 shows estimates of these discoveries made by Rystad Energy for this report. It indicates that the total volume of discovered resources in this region is about 2688 million barrels oe (oil equivalents).

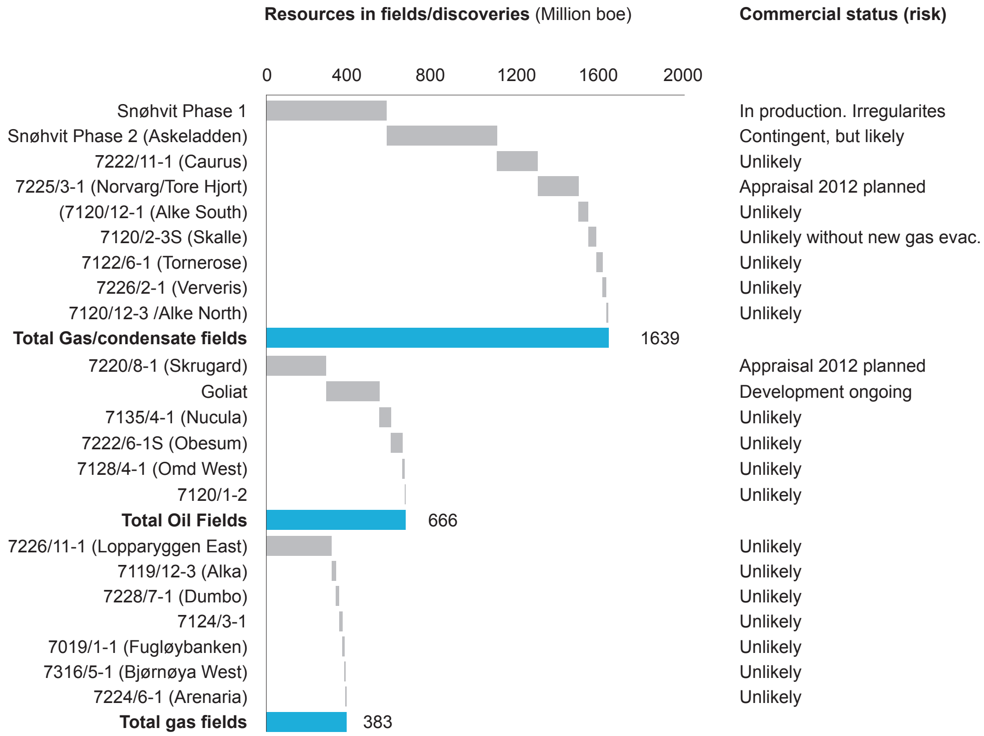


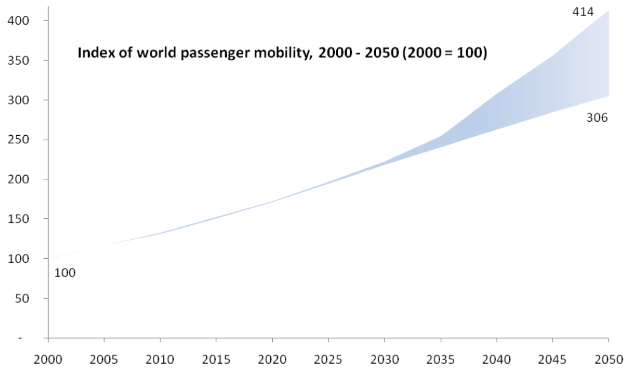
Figure 5: The chart outlines ultimately recoverable volumes for discoveries made in the Barents Sea. Only a few of the discoveries have concrete plans for development or further appraisal. (Rystad Energy 2011)

In comparison, 34 727 million barrels oe have been produced over the entire production lifetime of the Norwegian continental shelf (OD 2011). Newfound resources in the Barents area correspond to 7.7 percent of total production on the Norwegian continental shelf so far.

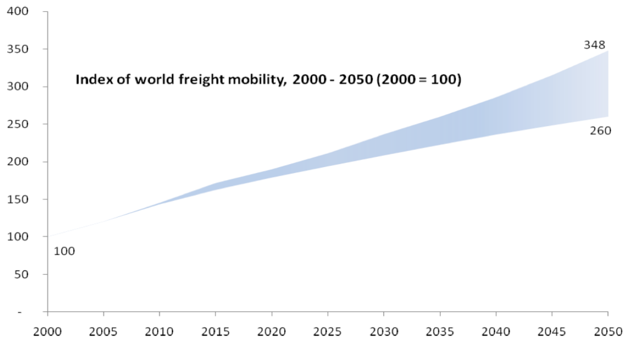
These trends imply that major amounts of petroleum still are to be transported over the coming years. While gas can pass through pipelines, oil must be transported by ship, and the projected trend is therefore an increasing transport of oil by ship out of the High North.

1.3.2 Transport: Increasing worldwide trade

Global trade flows have been steadily increasing for decades, driven by strong economic performance in developed countries. The recent financial crisis made a strong impact on trade, but already in 2011 global trade surpassed trade volumes from before the crisis.



1.6a



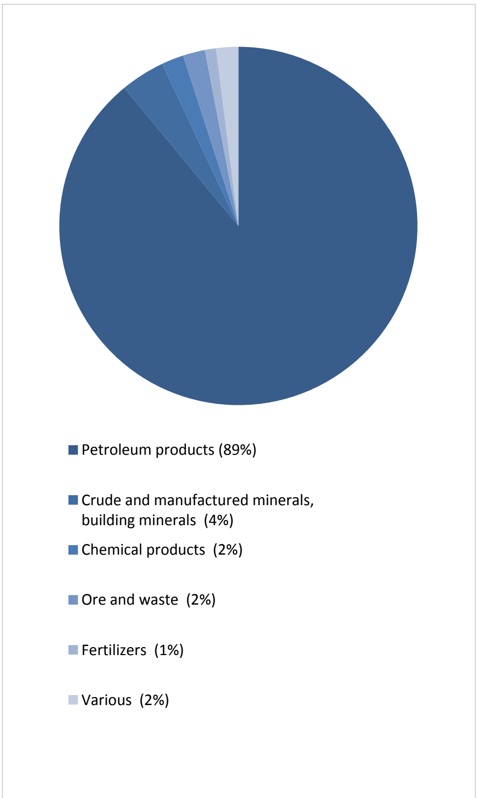
1.6b

Figure 6a: Index of global passenger transport activity, 2000-2050. Index of passenger-kilometers (2000=100). Figure 6b: Index of global freight transport activity, 2000-2050. Index of ton-kilometers (2000=100). (ITF 2011:11)

Overall trends in transport activity project further increases for the period of 2000-2050, according to the International Transport Forum (ITF 2011). Passenger mobility [passenger-kilometers] will increase by 3-4 times from 2010-levels (figure 6a) and freight activity [ton-kilometers] by 2.5-3.5 times (figure 6b), if infrastructure may sustain it and energy prices are reasonable. This will be driven by an estimated population of 9 billion people in 2050, with generally higher income levels.

It is expected that the largest driver of growth will be the non-OECD countries. While passenger-kilometers are expected to be 30-40 percent larger in OECD in 2050, a growth factor of 5-6.5 is expected outside the member countries. A major caveat is that «the high end of these ranges would be reached only if mobility aspirations in emerging economies mimic those of advanced economies and if prices and policies accommodate these aspirations» (ITF 2011:5). As with the

7a Liquid bulk



7b Dry bulk

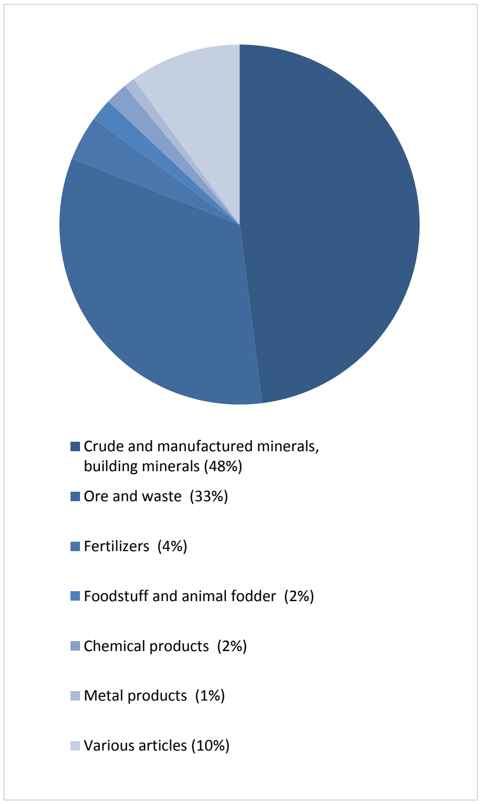


Figure 7a: Liquid bulk. Freight volume by type of commodity, 2007 (percent).
Figure 7b: Dry bulk. Freight volume by type of commodity, 2007 (percent). (SSB 2007)

economic gravitas, also the lion's share of transport increases may have shifted towards non-OECD countries by 2050.

In Norway, most sea transport is related to exports, according to the Sea Freight Transport Survey (SSB 2007). Transport between Norwegian and foreign ports accounted for 74 percent of total sea transport in 2007. Petroleum is a major driver of traffic, especially in the Northern region, with the gas installation Snøhvit outside Hammerfest and other large-scale projects on the way. In 2007, petroleum products constituted 89 percent of the total transported amount and 88 percent of domestic transport of liquid bulk (figure 7a).

Another driver of transport increases is mineral transport. It is the largest item in dry bulk shipping, comprising 48 percent of the total transported amount, and 77 percent of domestic transport (SSB 2007) (figure 7b). Mining will be an increasingly important economic factor also in the north, as newly discovered mining resources will be put in production. Currently, ship traffic is increasing out of the Ofoten fjord, as Narvik is shipping increasing volumes of iron ore from Kiruna every year.

A last factor that must be mentioned is the increasing traffic passing the Norwegian coast. A full opening of the Northern Sea Route will reduce shipping time from Hamburg to Yokohama by 40 percent, and cargo volume travelling this route is expected to increase rapidly. In 2010 1.8 million tons were sent through the NSR; the Russian Ministry of Transport estimates 64 million tons by 2020 (Barents Observer 2011). «We see the future of the Northeast Passage as that of an international transport artery,» said then Russian prime minister Vladimir Putin in September 2011 (The Telegraph 2011).

So, major increases are expected in the transport of goods and passengers. Such worldwide transport increases have implications for OSR. It implies an increased probability of vessels running aground, which in addition to human consequences also may cause spills of bunker oil. Increased transport will demand a development in the OSR worldwide.

1.3.3 Recent oil spills

The last decade has brought a number of oil spills in both international and Norwegian waters. These accidents have been caused both by ships running aground and incidents on offshore installations.

The biggest oil spill in history, the Macondo blowout in the Gulf of Mexico, occured in 2010. The amount of oil spilled is estimated to be over half a million cubic meters (Appendix 1), more than 20 times that of Exxon Valdez in 1989.

Recent oil spills in Norway has mostly come from ships running aground. Full City in 2009 and Server in 2007 caused significant damage on the Telemark and Hordaland coasts, respectively. Other larger spills from ships in the previous decade are Fjord Champion, Rocknes, Jon R, and Green Ålesund. The largest spill in the last decade was however from the Statfjord oil platform in the North Sea. This spill is estimated to be somewhere around 4400 cubic meters, and it was the biggest offshore oil spill since the (Ekofisk) Bravo accident (12 000 cubic meters) in 1977.

According to Bellona (2010), there were reported 2442 oil spill incidents in the period 2003-2008. Offshore activity was the main contributor with 8000 cubic meters of oil, over half of all oil spilled in the period. Even so, «oil spills from shipwreckings is the largest strain on the Norwegian coast» (Bellona 2010). Such accidents occur with irregular intervals along the whole coast, from the eastern Finnmark coast to the inner Oslo fjord.

1.4 Summary

The Norwegian OSR has come a long way since its conception only 40 years ago. But, as developments in energy and transport continue, the OSR need also develop. The trends show that the industry is facing new and greater challenges. In addition to this, the worldwide focus on environmental issues and challenges is ever increasing.

The problem statement for this thesis treats industrial opportunities and challenges in the Norwegian OSR market and how innovation can be strengthened in this industry. Before this can be answered one needs an understanding of how the Norwegian OSR system works today. Chapter 2 aims to give such an understanding as an empirical background for further discussion.

2 Oil spill response in Norway

This chapter contains extensive research conducted on Norwegian oil spill response (OSR). First, the fundamentals of OSR is presented—basic policy, the technology, and some historical development—as a background for what constitutes OSR. The chapters that follow describe the response system (the demand side), the industry (the supply side), the market conditions, and the support fro innovation and development.

2.1 The fundamentals

2.1.1 General emergency response policy

This chapter provides the policy background for Norwegian emergency response, which is the basis for the OSR system outlined in chapter 2.2.

Principles of emergency response

There are three main principles in the Norwegian political approach to emergency response. They are key to understanding the workings of the system (JD 2002:4):

1. The *sector principle* says that the government ministry that is responsible for the sector on a daily basis is also responsible for preparedness and management of an emergency.
2. The *proximity principle* says that crises should be handled at the lowest possible administration level.
3. The *similarity principle* says that the organization in peace and in crisis should be as similar as possible, as those who have the competencies in peace also are those best equipped to handle a crisis.

In other words, a crisis shall be handled by the same organization that has the pre-crisis responsibility, in an as similar organization as possible, on the lowest administration level possible. This means that emergency preparedness must be integrated properly in the system, as all levels of organization may be required to step in according to the gravity of a crisis, everyone from a local branch up to top-level management.

Division of responsibility

Three categories of responsibilities are identified for this general introduction to preparedness (SNL 2011):

- Political responsibility
- Responsibility for military preparedness
- Responsibility for civil preparedness

The responsibilities and pertaining actors are in many cases the same when it comes to preparedness in general and coastal preparedness specifically.

Political responsibility

Goals for emergency preparedness at the strategic level are set by the Prime Minister and the Cabinet (JD 2005a). These goals are translated into plans in the different ministries of government.

The Ministry of Justice coordinates the planning efforts of the different ministries, and is responsible for oversight and inspection agencies such as the Directorate for Civil Protection and Emergency Planning (DSB), Norwegian National Security Authority (NSM), and the Joint Rescue Coordination Centers. The Ministry of Justice is the governmental coordinator and supervisor of all emergency preparedness efforts.

Responsibility for military preparedness

Military emergency preparedness is cared for by the Chief of Defense and his staff. This planning aims to exploit all available military resources for the effective and efficient defense of the country.

Certain parts of the Norwegian military are on call, deployable in case of emergency. This pertains especially to the Home Guard, which is often called on in civil crises. (JD 2004)

Responsibility for civil preparedness

The responsibility for civil preparedness is that of the management of each single administrative body: counties, municipalities, firms et cetera. This is coherent with the sector and proximity principles.

As the proximity principle prescribes crisis handling on the lowest possible level, there must be a link between the central government and the local and regional governments as well as the private sector. This link is the county governor (Fylkesmannen 2011). In every county, a county governor has the coordinating responsibilities for the government. It also has the oversight function—ensuring that the municipalities comply with current legislation on risk and vulnerability analyses, fire protection, pollution, health issues, and other preparedness issues.

Legal framework

There are several acts that cover general emergency preparedness and response issues. Most important are the Pollution Control Act, which addresses general pollution, and the Petroleum Act, which addresses the petroleum industry. These have important impacts on Norwegian OSR.

The Pollution Control Act

This act is the main document governing the Norwegian emergency response, both on land and offshore. It sets up a system that handles planning, execution, and possible compensation resulting from a polluting incident. A division of responsibility and pertaining authority is made. This system is described in chapter 2.2. The act is enforced by the Ministry of the Environment.

The purpose of the Pollution Control Act is to shield the environment from pollution and reduce pollution from existing sources (Lovdata 1981). A major point of the act is that most pollution is defined as illegal without explicit permission beforehand. Any polluting enterprise must apply for a concession, and if given, such permissions are normally accompanied by a list of constraints. Concessions are handled by the Climate and Pollution Agency (Klif).

Another issue is that the polluter is bound to pay indemnities for any damages caused by its pollution, without regard to whether or not the polluter is to blame for the pollution event. This is known as the *Polluter pays principle*, and extends also to foreign subjects, e.g., ships.

Lastly, there are a number of obligations set forth: *an obligation to notify*, e.g. in the case of an oil spill; *obligation to respond and provide assistance,* if others are in an emergency; and an *obligation to provide information.* These obligations are made explicit to ensure a strong cooperation between the government and the private sector in case of a polluting incident.

The Petroleum Act

This act is the main document governing the Norwegian petroleum resources and the development of these. It governs all aspects of such development: exploration and exploitation permits, the awarding of block licenses, discontinuation of production, HSE requirements and preparedness, responsibilities and indemnities (Lovdata 1996).

§ 9-1 states that petroleum operations shall be developed in such a way that a high level of security and safety is *sustained and developed* along with technological development.

The act further states that any company participating in the petroleum industry shall develop plans sufficient for any incidents that may lead to injuries or loss of lives, pollution, or major material damages. The operator has a duty to ensure that measures are put in place to prevent or minimize any environmental damages. In case of a pollution incident such measures shall go as far as possible to return the environment to pre-pollution conditions.

Any operator is required to develop documentation of such contingency planning. This is to be submitted to the ministry as part of security and safety inspections (Lovdata 1996).

Additionally, in an amendment to the Petroleum Act, it is stated that the Climate and Pollution Agency (Klif) and the Petroleum Safety Authority (PSA) may require the stationing of emergency response at installations participating in the petroleum development. They may also, when particular reasons are present, instruct operators to cooperate with operators in other licenses. The agencies may also decide the terms of this cooperation, e.g., that financing of such cooperation shall be a collective responsibility (Lovdata 2012).

Summary

To summarize briefly, there are a number of actors involved in the system of emergency preparedness. On the ministry level, the Ministry of Justice coordinates cross-ministerial efforts. Crises are in general to be handled by the organization that is responsible pre-crisis, either this is a private organization, a municipality, or a county.

The three principles and two laws presented are especially important for the governance of emergency response. They have resulted in the OSR system described in chapter 2.2.

2.1.2 OSR technology

There are a number of technologies for oil spill detection and recovery. In addition to weathering—the natural process of dispersion of oil—five different technologies are explained. The first three technologies relate to the physical action of removing oil from water, the fourth deals with the detection and remote sensing of the oil, and the fifth is beach and land cleanup. These five are considered to be the most important and relevant countermeasures (Sintef 2010). A table with comparative information on the different technologies is available in Appendix 2. There are differing opinions regarding the efficiency of the oil spill countermeasures. However, there is consensus that one needs various methods of oil spill cleanup, and that different conditions requires different countermeasures.

The majority of the information regarding the following technologies is based on the Sintef report «Oil in Ice» (2010), and inputs from the interview with Sintef presented in chapter 5.

Natural weathering

Weathering of oil is a collective term for the chemical processes that occur when crude oil has been spilled into water. Examples of processes are evaporation, dispersion and oxidation. The lightest oil will actually evaporate off the sea, while heavier components may be mixed into the sea.

As a result of these processes the properties of the oil spill changes over time, and this affects which kind of oil

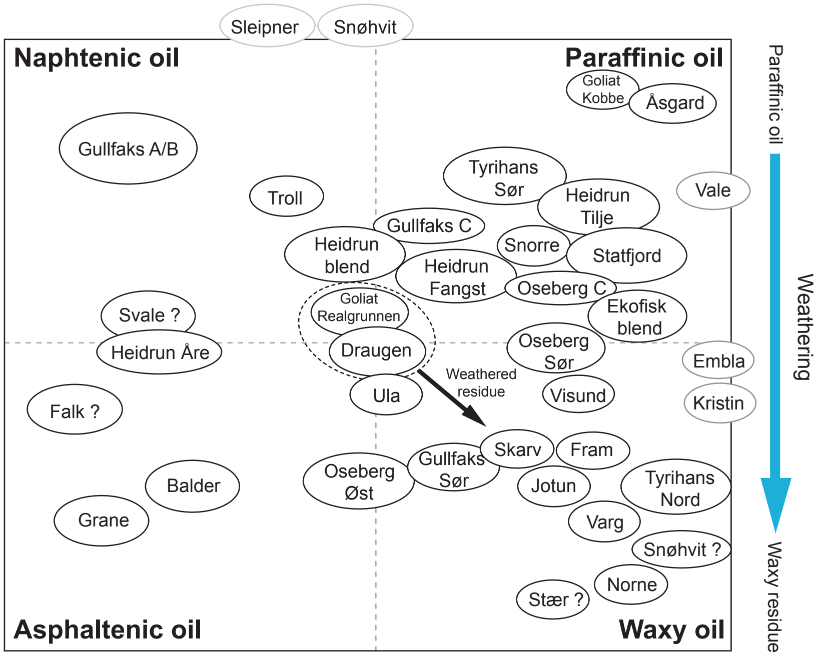


Figure 8: Norwegian oil fields distributed by oil properties (SINTEF 2011).

spill countermeasure that can or should be used. The different oil spill countermeasures operate with a «window of opportunity», which is the period of time it takes from the oil is spilled to the concerned countermeasure can no longer be used. To execute an effective and optimal OSR operation it is important to be aware of and align response with this window of opportunity.

There are several factors that influence the weathering of oil. They can roughly be divided into two categories. The first category is the oil properties, such as the viscosity and the emulsion stability. Figure 8 shows the chemical properties of the oil found in different oil fields on the Norwegian continental shelf. In case of an oil spill, knowledge of such properties is essential in order to choose the right countermeasure.

The second category is the climate and weather conditions such as temperature, winds and oceanic currents. In rougher weather conditions, oil will more quickly mix into the ocean and disperse.

Mechanical recovery of oil

Mechanical recovery is the default OSR action in Norway. One of the main benefits is that it both recovers and removes spilled oil. There are two main technologies dominating the market for mechanical recovery products: booms and skimmers.

Booms are large floating barriers that round up oil on the water. Most often they are connected to vessels or towing boats, but there also exist lighter, quick-response booms that can be operated or dropped from helicopters. Some booms are fireproof, making it possible to combine them with burning measures. The main drawback with traditional booms is that they have problems holding on to the oil when there are waves and when the current reaches approximately 1 knot. When the current surpasses 1 knot, relative to the boom, the oil may squeeze under the boom and escape. To deal with this problem, NOFI has developed the «Current Buster», an oil boom that can retain oil in currents up to 5 knots.

Oil skimmers are machines that pump oil into a recovery vessel. They are often used in combination with booms, where the booms gather the oil and the skimmers collect it. There exist a variety of skimmers, spanning from rather portable skimmers that can recover 20-30 m^3/h of liquid to large skimmers that can recover more than 350 m^3/h. Using different technologies these skimmers separate the oil from the water and store the oil in a tank. Many skimmers have different types of "hairy" fibers designed to make the oil stick. An issue with this technology is the need for storage space for the oil. The skimmers themselves often have low or

FACTS // North Sea vs. South Barents Sea

The climatic conditions in the South Barents Sea, which is the part of the Barents Sea that is opened for exploration, differ to some extent from the conditions found in the North Sea. First of all, visibility is an issue. Hammerfest (Finnmark), for example, has 2 months of total darkness (22nd November to 21st January), while Stavanger has more than six hours of daylight on the shortest day of the year.

The other main issue is the lack of infrastucture and the long travel distances on land, which results in much longer response times, and can lead to difficulties getting to the site of interest.

A last difference is the temperature, which is somewhat lower in the Barents Sea. The average January temperature in Vardø (Finnmark) is -5,1 degrees Celsius, while the average January temperature in Utsira (Rogaland) is 2,6 degrees Celsius *(yr.no 2012)*. Floating ice and icebergs are not an issue. In the South Barents Sea, is free of ice all year round *(NOFO)*.

no storage space, and must therefore be combined with a vessel or similar with a tank. This may not be a problem close to land, but can be when further out to sea. The properties of the oil are also of major significance in relation to how much the skimmers manage to collect.

Dispersion of oil

Instead of mechanically recovering and removing the oil, it is possible to disperse the oil into the water. This is a natural process where the oil is fragmented into small droplets and mixed with the water. The oil droplets will then spread, dilute and naturally biodegrade. By adding chemical dispersants to the spilled oil and mixing it with energy, one can speed up this process and disperse the oil faster. The way this is done is typically by spraying dispersants on the oil slick from a vessel or an airplane, and then adding energy by using the vessel propeller or jet to stir the water. Sintef has also developed a method to faster disperse oil with energy and no chemicals, but this has not yet been commercialized. Dispersion measures also operate with a window of opportunity, defining when the oil is too spread out for dispersants to be effective.

The effectiveness and environmental friendliness of dispersants depends on how they are applied. The amount of dispersants, the type of dispersants, the accuracy when applying the dispersants and the amount of input energy are important factors when measuring the effectiveness. Dispersion is not ideal in shallow waters with vulnerable ecosystems, as the dispersed oil will hit the seabed faster, and the chemicals themselves may also cause damage. In Norway there has been limited use of this technology. In other countries, such as Great Britain, the use of dispersants is more common and it has become be the main oil spill countermeasure.

In-situ burning of oil

In-situ burning is one of the most effective ways to remove oil from the surface of the sea, and often records an effective removal of over 90 percent There are however some conditions that must be fulfilled for in-situ burning to be possible. First and most important, the government must allow it. Many governments, including the Norwegian government, have traditionally been very restrictive on the use of in-situ burning, and in other countries it is completely forbidden.

If allowend it is crucial that the burning must happen within the window of opportunity. If the weathering of the oil has come too far, the oil will contain too much water to be ignitable.

Sintef has concluded that in-situ burning of oil is very effective in ice-covered waters. Following a potential

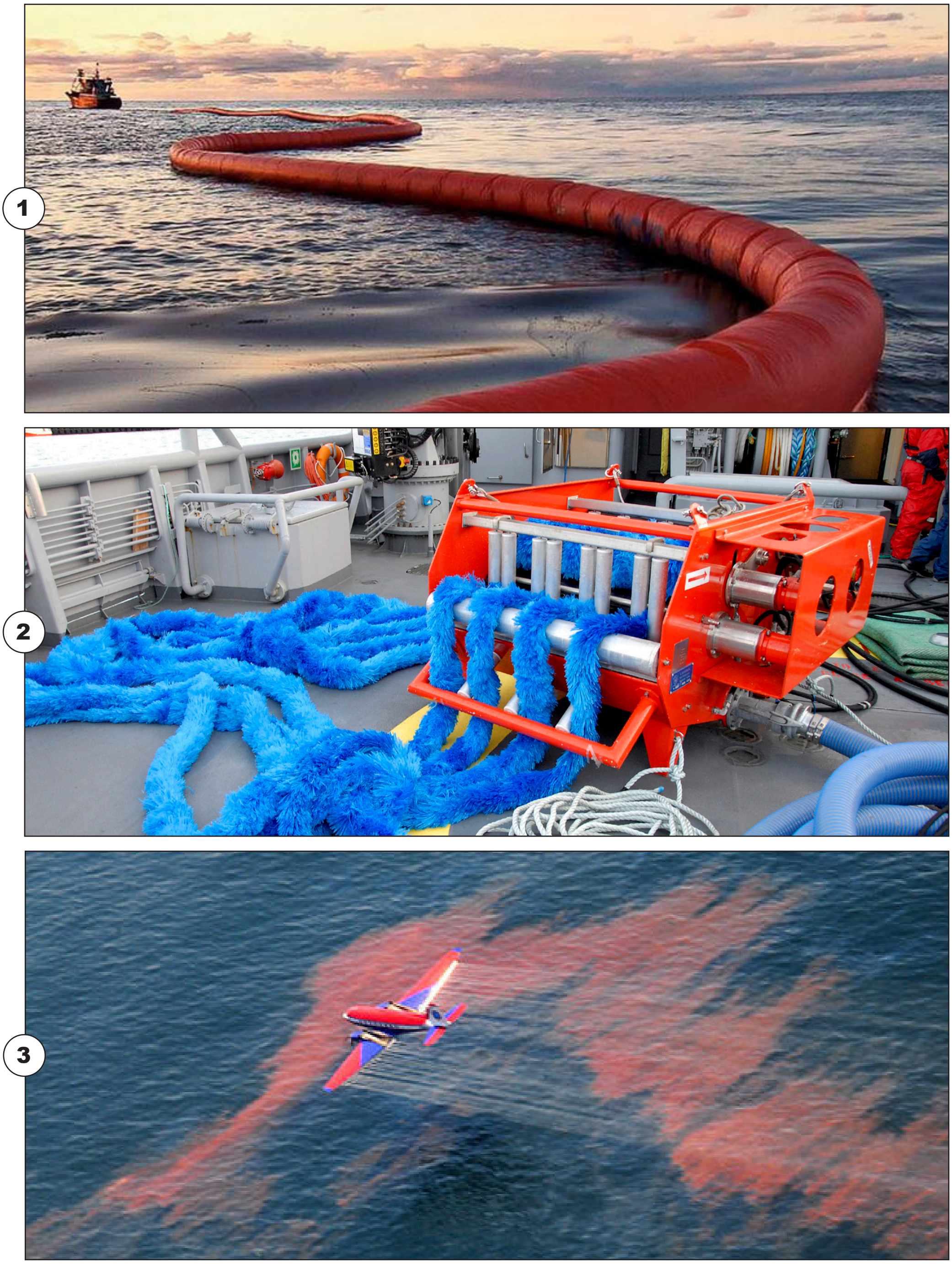


Figure 9: Images of OSR technologies. (1) Standard oil boom. (2) Foxtail skimmer. (3) Dispersion system mounted on an airplane. (4) Aptomar Securus system. (5) High pressure system for on-land cleanup. (6) In-situ burning of oil.

4

5

6

Sources: (1) aftenposten.no. (2) flickr.com/photos/geby (3) eoearth.org (4) tu.no. (5) wired.com. (6) cdn.theatlantic.com opening of the North Barents Sea, in-situ burning can become increasingly important.

It is possible to combine in-situ burning with fireproof booms to create thicker and more ignitable oil films and confine the fire to a smaller area. Even though the booms are fireproof, after in-situ burning most of them will need some repairing, according to a sales representative from the boom producer Desmi. Other disadvantages regarding in-situ burning are the polluting smoke and the visual pollution. According to Sintef, the supply of fireproof booms is relatively low.

Remote sensing of oil

Several types of equipment are used to detect oil spills. Some of the technologies are Side-Looking Airborne Radar (SLAR), Satellite-based Synthetic Aperture Rader (SAR), aircraft and vessel-based Forward Looking Infrared (FLIR) and Ground Penetrating Radar (GPR) operated from helicopters (Sintef 2010).

These technologies are used to find and measure oil spills, and further inform the choice of which oil spill countermeasure to use. In addition, they may give valuable information regarding the spreading, movement and size of the oil spill. The closer to the poles, the more important this sensing equipment will be, due to the long period of winter darkness, making it impossible to see oil spills without technical assistance. Harsh weather is also a factor that makes it difficult to operate without this kind of equipment.

Remote sensing can not be used as the only countermeasure for spilled oil, since it does not actually remove or disperse the oil in any way. It can only be used as a support function for one or more of the previously mentioned methods.

Beach and on-land cleanup

This kind of oil spill countermeasure is used when the oil reaches land. The common way to remove oil from land is to use absorbents and vacuum or high pressure water systems. Some companies specialize in oil spill removal, e.g., Kaliber Industridesign and Abtek AS. However, there are also a lot of companies that have equipment used to remove oil from land, but that are active mainly in other industries. Thus, it is a time-consuming task to summarize all companies active in this part of the industry. Equipment for beach and on-land cleanup will therefore not be discussed in detail in this thesis.

Summary

This chapter has explained three different technologies of removing or dispersing oil, one technology for sensing and detecting oil, and briefly mentioned how beach and on-land cleanup is done.

A challenging aspect is the variety of technologies that exist, spanning from mechanical devices like booms and skimmers to chemical dispersants and high-tech instruments. Because of this variety it is challenging to analyze the OSR market as a single market, but due to the relatively small size and specific market for the products it is feasable to include all technologies used for OSR on water.

2.1.3 The historical development of the Norwegian OSR

With a general understanding of emergency response policy and technology in mind, this last introductory chapter sketches the development of Norwegian OSR. The current system will be described in detail in chapter 2.2.

Only half a century ago, there was no oil activity in Norway and consequently no OSR in place. The brief account of the development presented here is sourced entirely from the book «Norsk oljevern gjennom 40 år» by Ottar Longva (2012).

Organizational development

In 1971 the Oil Spill Council (Oljevernrådet) was established as the first governmental actor in the field of OSR. The creation of this council was mandated in the first Norwegian act on protection against harm from oil, which itself stemmed from a 1954 international convention on oil pollution. In the almost 20 years that had passed from the convention to the formal establishment of the council, Norway had found oil and was now starting to prepare for possible negative consequences.

The council was only a few years later incorporated into the National Pollution Agency (SFT), the state oversight agency for general pollution. SFT had previously served mostly as an analytical tool, but now also an operational role was added in the area of OSR, necessitating the creation of a specific OSR department in SFT. This event marked, in 1976, the real start of a national response to oil pollution.

Further organizational consolidation was proposed in 1977. The practical knowledge of how to combat oil spills was located at the Main Station of Oil Spill Response Ltd. After the Bravo accident, a major blowout on the Bravo platform of 12 000 cubic meters (9600 tons) of oil, weaknesses in the OSR organization were assessed. It was decided that the Station and its practical capacities was to be included into SFT the following year. Their main task would be to develop and maintain all governmental OSR equipment.

Longva (2012:24) notes that there was resistance to this merger (translated from Norwegian):

> *Some were of the opinion that a governmental oversight agency should not administer the responsibilities of an operational preparedness of which they also were responsible for supervising. This was seen as a situation where the fox would be minding the geese. [Norwegian idiom translated: å sette bukken til å passe havresekken]*

As a personal comment, Longva (2012) notes that this was a pioneering time, and that such consolidation of knowledge may have been considered crucial for further development of the OSR.

Already in 1978, funding for regional and local OSR was secured in the budget of the Ministry of the Environment. The amount of funding varied over the years, but in general made it possible for municipalities to acquire very good equipment.

NOFO, the Norwegian Clean Seas Association for Operating Companies, was also established in the aftermath of the Bravo incident. This organization operates and coordinates the response of all operating companies on the Norwegian continental shelf, and will be further discussed in chapter 2.2.1.

In 2003, the responsibilities for governmental preparedness against acute pollution were transferred from SFT to the Norwegian Coastal Administration (NCA), which is the oversight agency in coastal affairs. SFT (now known as Klif) retained the task of specifying demands towards polluting industry, such as oil companies. All planning and operational tasks in OSR were transferred to the NCA. Broadly speaking, this is how the organization remains today.

Equipment development

In the period 1971-1975, the central stock of OSR equipment comprised only 2800 meters of oil booms, two 30-foot boats, and a single hydraulic pump.

In 1976, with the Oil Spill Council merged into SFT, the first six governmental depots for oil spill equipment were established along the coast. Another six depots were set up over the years of 1978-1979.

In this period of expansion of the OSR, there was a continuous debate on the quality of the equipment. How good was the equipment one had access to? According to Longva (2012:70), there was «an evident potential for technological development». In 1978, 77 MNOK was designated OSR over the National Budget (from 29 MNOK the year before), funding a four-year R&D program for innovation in equipment.

Extensive testing was undertaken, among them the Oil on Water exercises (chapter 2.2.5). The first of these was

1


Bellona kritiserer regjeringen etter at lasteskipet «Full City» gikk på grunn natt til i går:

– For dårlig beredskap

MANGEL: – Oljevernberedskapen har vært under enhver kritikk, sier Bellonas Marius Dalen. – Utstyret har begrensninger, innrømmer Kystverket.

Facsimile 1: *The Full City shipwreck, 2009* (Klassekampen).

2


10 TORSDAG 13. DESEMBER 2007 VG

OLJEKATAST

UTBLÅSING: Bravo-ulykken i 1977. Et hjelpefartøy sprøyter vann på riggen. Foto: SCANPIX

Fadesen på Statfjord

Fadesen på Statfjord A er det nest største utslippet i norsk oljehistorie.

Det rapporteres at mer enn 3800 kubikkmeter olje har lekket ut; det tilsvarer 24 000 fat. Ved utblåsingen på Bravo-plattformen i 1977 var utslippet tre ganger så stort.

I tiden som kommer bør det reises en rekke kritiske spørsmål om hvordan dette kunne skje. Hvorfor hadde man ikke rutiner for varsling slik at bøyelastingen kunne stanses straks lekkasjen oppsto? Brukte man gammelt og slitt utstyr som burde ha vært skiftet ut for lengst? Osv.

For det er jo merkverdig at så mye olje kunne lekke ut uten at noen grep inn. Man skulle tro at det fantes fjellstøe rutiner for varsling og for å hindre at slikt som dette i det hele tatt kunne skje. Her må rette vedkommende myndigheter gå tungt inn og granske både årsaks- og ansvarsforhold.

StatoilHydro som er ope-

meget krevende prøve.

Dersom oljen driver videre nordover i havet uten å nå land, tyder alt på at skadevirkningene etter uhellet blir sterkt begrenset, for ikke å si ikke-eksisterende. For da kommer havet til å bryte ned oljen og renske opp uten menneskelig medvirkning.

Utslippene fra Bravo-utblåsingen i 1977 var som sagt tre ganger så store. I tiden etterpå ble de ikke registrert en eneste skadevirkning på miljøet. Naturen har en forunderlig evne til å renske opp selv, og livet i havet tar åpenbart liten eller ingen skade selv av et veldig stort oljeutslipp.

Men det betyr selvfølgelig ikke at det som har skjedd ikke er alvorlig. Det må settes i verk kraftfulle tiltak for å forhindre at slikt som dette hender igjen.

Facsimile 2: *The Statfjord oil spill, 2007* (VG).

3


Store olje-utslipp

Forbereder seg på oljekatastrofe

USAs naturmyndigheter forbereder seg på miljøkatastrofe etter at utslippene fra oljeplattformen Deepwater Horizon, som sank i Mexicogolfen i forrige uke, ikke stopper.

Facsimile 3: *The Macondo blowout, 2010* (Dagsavisen).

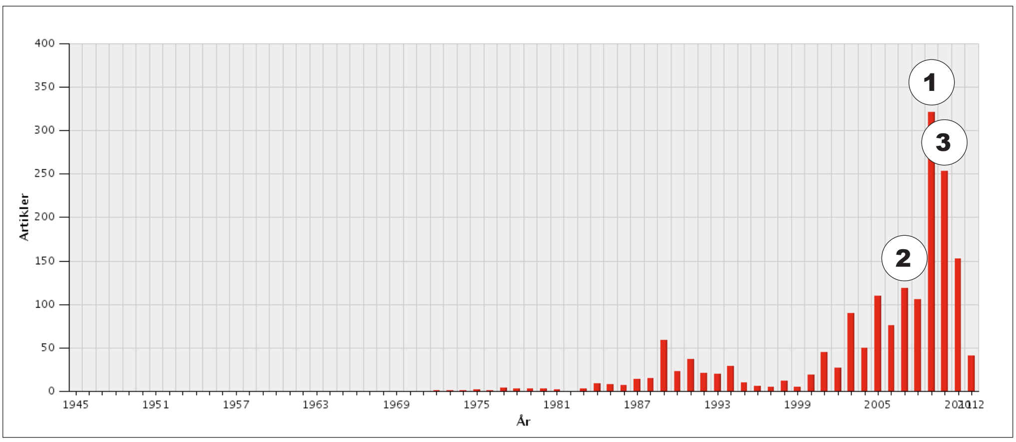


Figure 10: OSR in the media. The graph shows the distribution of results for the search term «oil spill response» («oljevernberedskap») in the Atekst news database. Peaks in media attention correspond to major oil spills (atekst.no 2012).

held in 1980. The following year the NCA and NOFO initiated joint exercises, which have been held since.

Such testing resulted in the development of the Foxtail Skimmer, which was patented by the NCA and is produced by Henriksen Mekaniske Verksted.

The Armed Forces were included in the national OSR in 1993, when six large Coast Guard vessels were outfitted with OSR equipment. This happened as a consequence of failing to maintain a fleet of fishing boats with such equipment, as this responsibility interfered in periods with their other work at sea. The collaboration between the Coast Guard and the NCA increased through this decade, with the establishment of an Inner Coast Guard and closer coordination of the Coast Guard and OSR needs.

Today, 11 Coast Guard vessels are equipped for OSR. According to Longva (2012:75), «the Coast Guard with its mobile depots constitute one of the main elements in the national OSR». They come in addition to the 16 depots on the coast, which contain approximately:

- 10 000 meters of oil booms for open ocean
- 23 000 meters of oil booms for coastal waters
- 10 000 meters of oil booms for «shielded» waters, e.g., fjords
- 130 devices, mostly skimmers and other pumps
- 9 emergency-unloading bundles for unloading shipwrecks

Other resources such as surveillance airplanes and automatic tracking systems for vessels (AIS) are widely used.

In addition, private and regional resources are integrated into the national response system. This response system is the topic of the next chapter.

2.2 The system for OSR

The national system for OSR is a three-tiered structure, where each level has specific responsibilities. In the event of an emergency, these levels are supposed to work in an integrated manner

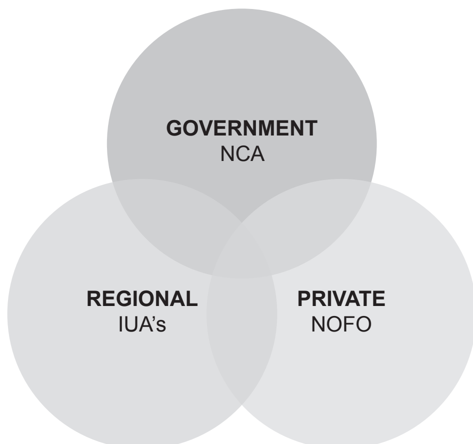


Figure 11: The three spheres of the national response system. (NOFO n.d.).

as a single response organization. The response levels are: the private level, the regional level, and the governmental/ national level (figure 11 & figure 12) (DSB 2011).

2.2.1 Private actors

There are about 70 private actors that are required by the government to hold their own adequate level of preparedness (NCA 2011a). These are typically operators on the continental shelf, oil terminals onshore, refineries and similar facilities. Major industrial plants that could cause significant oil pollution are likewise required (ITOPF 2008).

The major private actor is the Norwegian Clean Seas Association for Operating Companies (NOFO). The purpose of NOFO is to ensure that companies operating offshore comply with governmental contingency requirements (ITOPF 2008), and that they have sufficient planning and equipment to be able to handle an oil spill accident. It is a non-profit organization, and is always operational.

It administrates a major part of the response resources for its member companies (NOFO 2011a). However, this does not mean that NOFO absolves the oil companies of responsibility for an oil spill. The oil company as the polluter is responsible for combatting the spill, and NOFO aids in this work with tactical and operational command of available

FACTS // NOFO Resources

- 27 full-time employees
- 50 reinforcement personnel from oil companies
- 5 oil spill response bases with 80 operators
- 25 oil recovery vessels
- 25 towing boats
- 20 sea-going mechanical oil recovery systems
- Stock of oil spill dispersants
- Remote sensing of the continental shelf
- Oil recovery equipment for coastal operations with access to fishing vessels
- Shoreline task force of 50-60 people, for shoreline operations
- Collaboration agreements with the NCA and the Inter-municipal Boards for Acute Pollution (IUA). If a major pollution event should occur—even though not related to members of NOFO—it may be required to aid in the operation. The stockpiles of NOFO are then put to use by the NCA or other actors.

(Source: NOFO n.d.)

Private actors (70)	Regional actors (33)	National actors (4)
NOFO: BP Norge AS ConocoPhillips Norge ExxonMobil E&P Norway AS Total E&P Norge AS A/S Norske Shell Eni Norge AS RWE Dea Norge AS Hess Norge Statoil ASA Chevron Norge AS Marathon Petroleum Co DONG E&P Norge AS Talisman Energy Norge Lundin Norway AS Det norske oljeselskap BG Norge Ltd VNG Norge AS Wintershall Norge ASA Norwegian Energy Company GDF SUEZ E&P Norge Suncor Energy Norway AS Centrica Energi Faroe Petroleum Norge Premier Oil Norge AS Maersk Oil Norway AS Idemitsu Petroleum Norge AS E.ON Ruhrgas Norge AS OMV Norge AS Rocksource ASA LOTOS Expl. & Prod. Norge AS -- 40 other private actors in addtion to the 30 NOFO members.	Østfold IUA Romerike IUA Indre Oslofjord IUA Buskerud, Sande og Svelvik IUA Hedmark IUA Oppland IUA Vestfold IUA Telemark IUA Aust-Agder IUA Midt-Agder IUA Vest-Agder IUA Sør-Rogaland IUA Nord-Rogaland/Sunnhordl. IUA Bergen region IUA Hardanger IUA Sogn og Sunnfjord IUA Nordfjord IUA Sunnmøre IUA Romsdal IUA Nordmøre IUA Sør-Trøndelag IUA Inntrøndelag IUA Namdal IUA Helgeland IUA Rana IUA Salten IUA Ofoten IUA Lofoten og Vesterålen IUA Sør-Troms IUA Midt- og Nord-Troms IUA Vest-Finnmark IUA Midt-Finnmark IUA Øst-Finnmark IUA	Norwegian Coastal Administration (NCA) The Climate and Pollution Agency (Klif) The Norwegian Maritime Authority (NMA) The Petroleum Safety Authority (PSA)

Figure 12: The three spheres each involve a number of different actors. (SINTEF 2011).

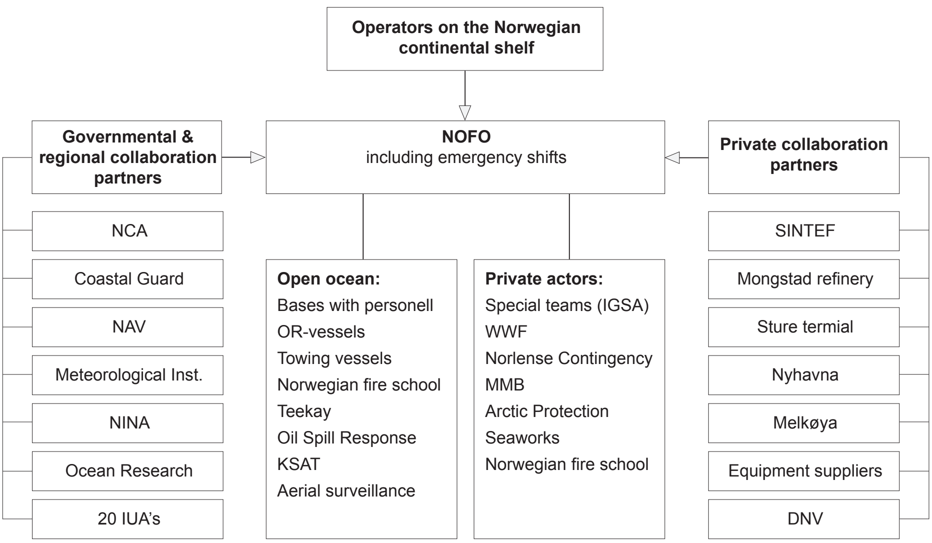


Figure 13: NOFO partners/resources (SINTEF, 2011:17).

resources for OSR. Its partners are listed in figure 13.

NOFO maintains the largest non-governmental stockpiles of oil-spill response equipment in Norway. There are 5 depots along the coast, located in Stavanger, Mongstad, Kristiansund, Sandnessjøen, and Hammerfest (figure 16). The total recovery capacity is estimated to be 100 000-200 000 barrels of oil per day (NOFO n.d.).

There are 30 member companies in NOFO today. Recent years has seen a marked increase in members, as an increased number of smaller companies have entered the Norwegian continental shelf. These companies may have limited experience with OSR, and an important task for NOFO is to provide information on Norwegian law and practice.

Another private actor is the Operators' Association for Preparedness (OFFB). Unlike the major oil companies that have departments for emergency preparedness in-house, small oil companies with limited experience and resources generally do not. This is a compliance issue, as governmental regulations demand that all operating companies should have access to sufficient contingency resources to handle an oil spill. While NOFO is an operational organization, OFFB is supposed to be a substitute for this in-house department for emergency preparedness, supplying a command central and the required knowledge for emergency operations. OFFB was established as late as March 2010 (OFFB 2012).

2.2.2 Regional actors

Acute pollution resulting from «normal» activity in the municipality is the domain of the local authorities. But for each municipality to organize its own emergency preparedness would prove inefficient. Therefore, the local responsibility is coordinated on a semi-regional level, as shown in the example of Lofoten and Vesterålen IUA on the page.

The local/regional emergency preparedness level consists of 33 Intermunicipal Boards for Acute Pollution (IUA), which cover the 430 municipalities of Norway. Each board is responsible for the creation and maintenance of a contingency plan for its designated area.

Municipalities are obligated to assist the government if a major event should occur. A contingency plan is drawn up to ensure that assistance will be provided if the need arises (ITOPF 2008). Also many IUAs around the country have made agreements with NOFO on use of equipment in case of emergency.

In most IUAs around the country funding is a critical issue. Funding is to a large extent associated with the

EXAMPLE // Lofoten & Vesterålen IUA

Figure 14: The IUA of Lofoten and Vesterålen.

The equipment situation in IUA Lofoten and Vesterålen was subject of a thorough review in 2009. The review concluded that all 8 depots had deficits. In several instances there was no personal protection gear available, or technical equipment such as compressors. In some depots the oil booms could not be used. In one instance, the door of the container that held the equipment was rusted shut and could not be opened. *(Nordnorsk Beredskapssenter 2009)*

EXAMPLE // Kautokeino IUA

The voluntary aspect of IUAs was exemplified with Kautokeino IUA. In an OSR exercise in Finnmark, the participants from the IUA were sent home after 1 day due to the weakened emergency fire response in their absence *(Anonymous personal communication).*

population in the municipalities covered, which means that some will have a larger amount of funds, like the IUAs in the Oslo and Bergen regions, while others, where population density is low, may have very little. Where funding is scarce, courses and training of key people in the area may take up most of the budget. Many IUAs have therefore come to depend on funding and equipment from NCA. In 2012, NCA has been granted 15 MNOK to improve this situation.

IUA preparedness has traditionally been based on volunteers. This is not the case today. The IUAs are based to a large extent on resources in fire brigades, police departments and similar emergency-related entities. Likewise, the chairman of the IUA is often the fire chief or harbor master in the area. Most human resources in IUAs around the country are employed, and their training in OSR comes in addition to their daily duties elsewhere. One consequence of this organization is that use of personnel, both in training exercises and in real-life response, will be limited due to other responsibilities.

The IUA organization has been subject of debate in recent years, as when the IUA around Bodø could not find anyone to chair the IUA. Qualified candidates such as the harbor master and fire chief refused due to the position being only part-time, citing the nation-

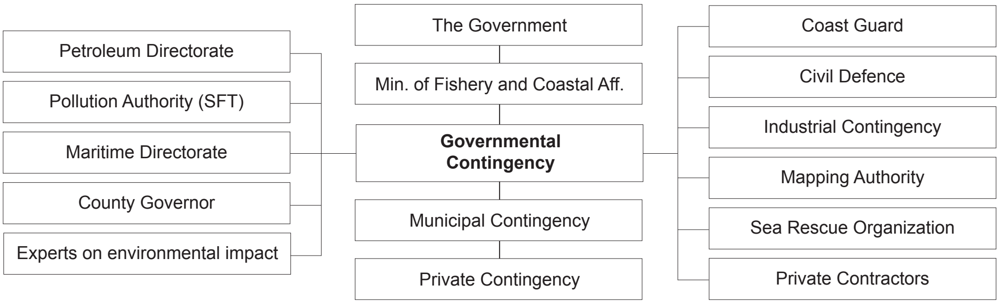


Figure 15: Governmental contingency structure (NCA 2003).

wide organization of IUAs as «unprofessional» (Avisa Nordland 2009).

2.2.3 National actors

The government agency responsible for emergency preparedness on the coastline is the Norwegian Coastal Administration (NCA), which reports to the Ministry of Fisheries and Coastal Affairs.

The domain of NCA is the areas that are not covered by private or regional preparedness. This often entails oil spills from ships or shipwrecks (NCA 2011a), or pollution from unknown sources.

NCA has several important roles. They keep surveillance on the transport activity on the coast through Vessel Traffic Service (VTS) centrals. Should an event of pollution occur, NCA in the role of an *oversight agency* would see to that the polluter or municipality takes the actions necessary to combat it. If the actors are unable to do so, the NCA in the role of an *emergency response organization* will seize control of the operation. The NCA also has the *overall OSR coordinating authority*, ensuring that all separate contingency systems form a single national emergency response system.

	Private/Public	Owner	Jurisdiction	Financing	Supervisor
NCA	Public	The Norwegian government	General responsibility for OSR in Norwegian waters	Over the national budget	NCA
NOFO	Private	Oil companies operating on the Norwegian continental shelf	Supportive role. Oil companies are individually responsible for OSR.	Membership fees	NCA

Table 1: Differences between the two major buyers.

FACTS // The Norwegian Coastal Administration (NCA)

Facts about NCA:

- 16 oil spill response depots, each manned by 11 people, and stocked with oil booms, oil skimmers, technical and personal equipment.
- Dimensioning size for Norwegian OSR:
- 50 employees in the NCA Emergency Response Center.
  A single accident of maximum 20,000 m3
- Annual grant to cover equipment investments:
  9,3 MNOK (indexed)
- Total extra grant to cover the gaps pointed out in the 2000/2001 Emergency Preparedness Analysis (EPA):
  340 MNOK (2006-2010)
- Total extra grant to specific follow-up of the municipal oil spill preparedness:
  15 MNOK (2012)

Main tasks in technology development:

- Planning, purchasing and management of all state emergency response resources for acute pollution.
- Operation and follow-up of the 16 OSR depots
- Responsible for equipment and operation of both NCA's and Coastal Guard vessels that have OSR equipment on board.
- Partly responsible for national and international cooperation for resource support.
- Responsible for R&D initiatives, further development of OSR equipment.
- Responsible for operation of the NCA oil test facility in Horten.
- Responsible for follow-up of emergency response agreements.
- Responsible for safeguarding the logistics function related to state OSR operations.

NCA handling of oil spills from ships:

- The tort-feasors, which can be the ship-owners or ship-operators, are fully responsible for all pollution.
- NCA orders the tort-feasor to carry out an OSR operation.
- If the ship-owner or ship-operator does not have the resources to carry out an OSR operation, NCA mobilizes an OSR force that carries out the operation on behalf of the tort-feasor.

(Source: Steinar Lodve Gyltnes, personal communcation 28th March 2012)

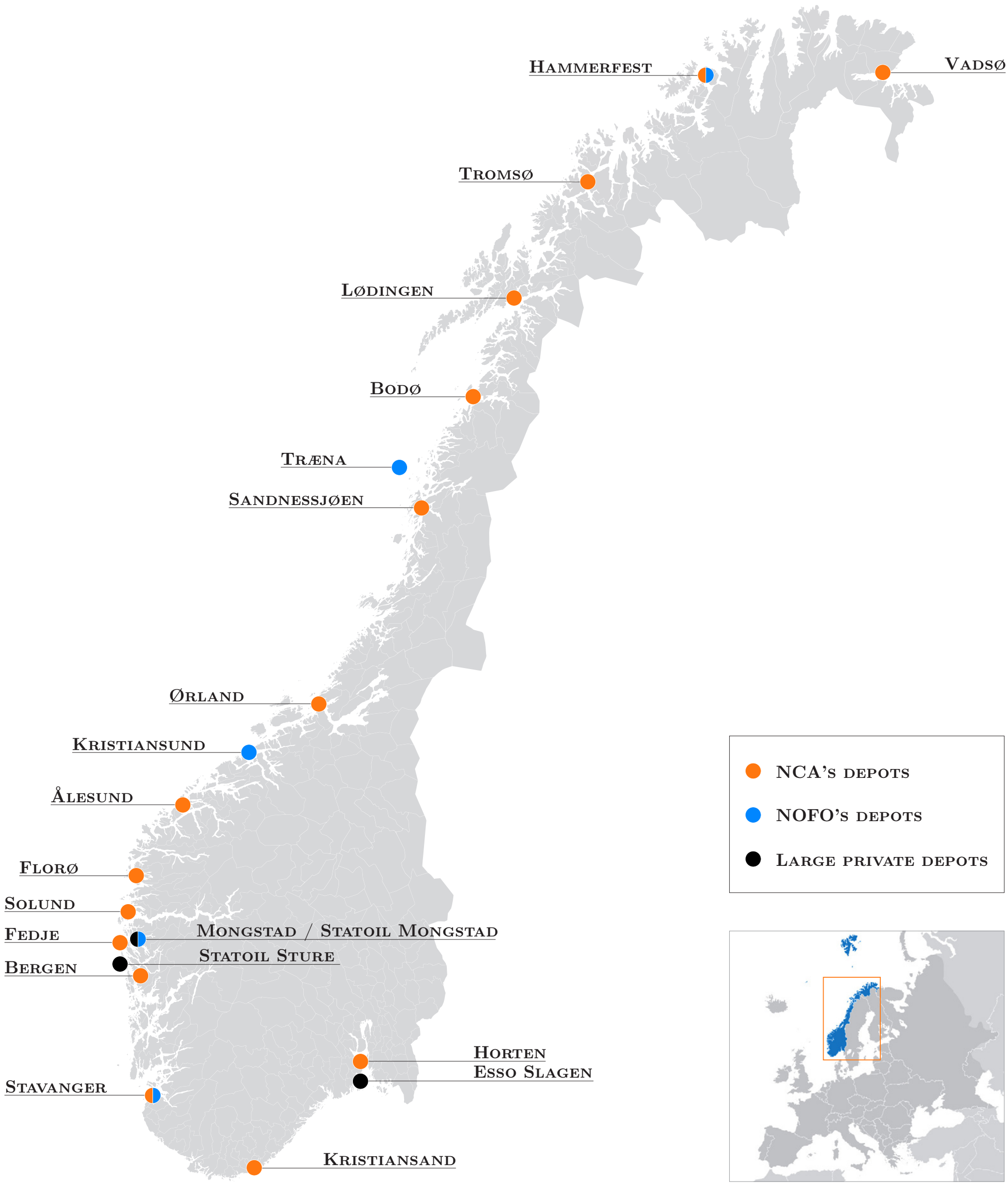


Figure 16: Map showing 15 of 16 NCA depots (1 on Svalbard), all 5 NOFO depots and 3 large private depots (NCA 2012a).

FACTS // Other governmental agencies involved in OSR

The Climate and Pollution Agency (**Klif**) is the governmental agency that sets requirements for emergency preparedness. Where pollution permits are given, Klif sets the terms and conditions that accompany the permit. It is the governmental unit that develops laws, administrative regulations, and guides for handling acute pollution. When acute pollution happens, Klif advises the organization with the responsibility for handling it, whether it is a private company, an IUA, or NCA (Klif 2012).

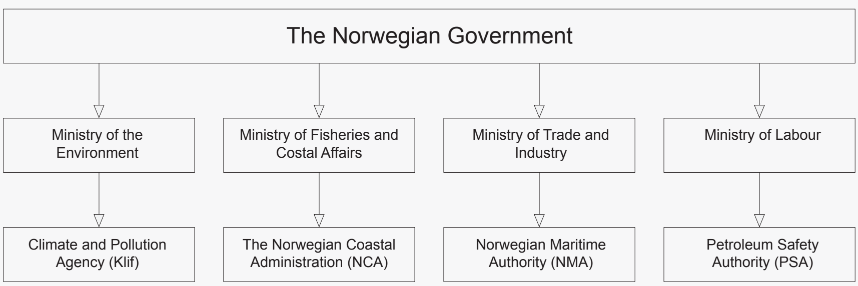
The Petroleum Safety Authority (**PSA**) sets the premises for health, safety & security, and environment (HSE)—including emergency preparedness—and acts as the oversight agency specifically for oil companies on the Norwegian continental shelf. PSA enforces the Petroleum Act (PSA 2011) and is aided by the NMA in this work.

The Norwegian Maritime Authority (**NMA**) is the government agency responsible for ships registered in Norway and foreign ships calling at Norwegian ports. The Director of the NMA reports to the Ministry of Trade and Industry (NMA 2011). When a vessel is on the way to becoming a source of pollution, the NMA supports the NCA. This support may take the form of emergency tugging, emergency unloading, or bringing the disabled vessel ashore (NCA 2011b).

Differentiation of responsibilities:

- In development: Klif verifies that requirements were met.
- In operation: PSA supervises the technical facilities of the oil companies.
- In an emergency: NCA supervises the specific pollution situation, and ensures a sufficient OSR. NMA assists.

The 4 agencies sort under 4 different ministries, as shown below:



In addition there are 3 more ministries with direct OSR involvement, bringing the total to 7 ministries:

- Ministry of Petroleum and Energy: Finances the majority of OSR-related development support from the government.
- Ministry of Justice: Runs the Directorate for Civil Protection and Emergency Planning (DSB), the Joint Rescue Coordination Centers, the Civil Defense.
- Ministry of Defense: Runs the Norwegian Armed Forces.

2.2.4 Key principles

In chapter 2.1 the three key principles for the governmental contingency system was described: the sector, proximity, and similarity principles. In OSR, specifically, there are also some basic principles that are key to understanding the approach (NCA, 2011b:13).

1. Saving lives comes first. When lives are at stake, all resources are devoted to this task, even though there is a serious oil spill occurring.
2. The oil spill preparedness is based on risk assessments, probability multiplied with consequence. It is generally not dimensioned for a worst-case scenario.
3. All available resources may be commanded and used in major environmental combat operations. The government may require the use of private equipment.
4. Mechanical methods have priority. This includes oil booms, skimmers, and other equipment that collects and removes oil from the water.
5. Chemical methods like oil dispersants may be used if a Net Environmental Benefit Analysis (NEBA) shows that they will reduce overall environmental impact.
6. An oil spill is combatted as close to the source as possible.

When it comes to the system of OSR, there is one principle developed by the industry that is widely used to organize resources. This is the *barrier principle*, and it integrates some of the principles mentioned above.

In the oil industry's barrier principle, five barriers are designed to minimize the risk of a spill and mitigate any potential environmental damages (figure 17). The principle is designed by NOFO. The barriers are (Sintef 2011:10):

0. Preventative measures on the oil installation
1. Actions to combat the spill on open sea
2. Actions to combat the spill drifting towards the coast
3. Actions in the coastal zone
4. Clean-up actions on land

The barrier designated «0» refers to actions taken to prevent an oil spill in the first place. This may be elevating the edge of a platform deck to collect any spilt oil or chemicals, increasing the number of safety valves on systems with risk of leakages, installing blowout protection, and other safety measures.

Barrier 1 is the first vessel(s) arriving at the spill. Contingency equipment employed here is any equipment carried by such a vessel, such as simple oil booms or skimmers. The equipment is operated by the ship's own crew (OLF 2010).

Barrier 2 is set up by dedicated «contingency vessels» that are in the area or stationed on the coast. These vessels carry more specialized oil-spill response equipment, which is operated by NOFO personnel brought aboard when the vessel is mobilized to action. Larger towboats are normally also used here to move larger oil booms into position (OLF 2010).

Barrier 3 aims at stopping an oil spill from drifting onshore. Specialized oil booms for use in stronger water currents may be used here. Vessels involved in this barrier may be both dedicated contingency vessels and other vessels set up for combatting oil spills, such as fishing boats certified for OSR. IUAs will normally be involved in this part of the operation.

Barrier 4 is coastal cleanup when a spill has reached land. This is normally a barrier operated by the IUAs.

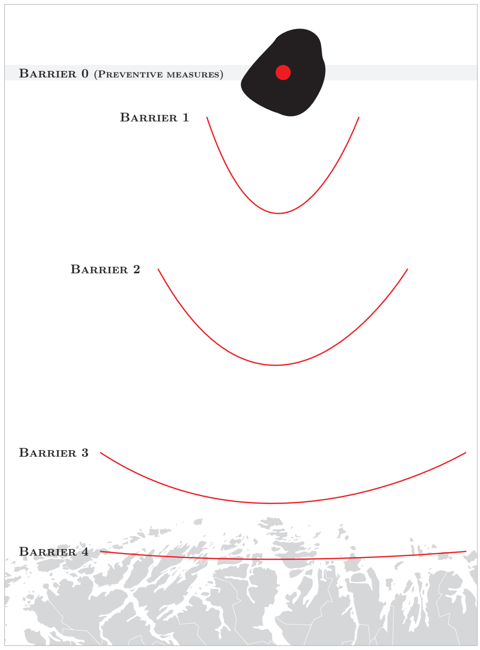


Figure 17: The barrier principle (NOFO n.d.).

2.2.5 Training and exercises

NCA and NOFO are both active in training and exercises to maintain an effective OSR. Overviews of NCAs and NOFOs 2012 exercise schedules are included in Appendix 4 and 5.

In the NCA schedule, there are four major exercises planned (highlighted in blue). These include international collaboration, e.g., with Russia. The green entries are regional exercises of the depot resources. These are physical training in setting out oil booms, securing the shoreline, and physical removal of oil from water. 11 such exercises are to be conducted throughout 2012. In addition, the orange-colored entries are table-top exercises for IUAs around the country.

In the NOFO schedule, there are exercises planned for oil spill detection and use of dispersants (week 18 and 37) and for the special shoreline task force IGSA (week 11, 12, and 45). There are also two full-scale exercises planned,

FACTS // Oil on Water

Norway is one of very few countries in the world allowing for the controlled discharge of oil onto water for the testing of equipment. These Oil on Water exercises are conducted yearly, and this is the only exercise where equipment producers can test equipment in a real-life situation.

Oil on Water has been conducted since the early 1980's, resulting in valuable knowledge both for NCA and NOFO, and for Norwegian equipment producers. Until 1995 only mechanical methods were tested. Now also chemical methods and detection equipment such as sensors are tested. The knowledge gathered from these exercises is used for further development of equipment and for dimensioning the Norwegian OSR. *(Longva 2012)*

Although the success of these exercises has been established, there has been expressed concern about how far the knowledge gathered can be extended. Such concerns are primarily based on the small volume of oil discharged relative to an average-sized or larger oil spill.

and the yearly Oil on Water exercise. In addition, NOFO runs courses and seminars such as basic OSR, advanced OSR for captains/first officers, and specific IUA courses. NOFO also participates in exercises run by the NCA.

2.2.6 Summary

Planning for and maintaining sufficient acute pollution preparedness for the government is the role of NCA. Private companies and IUAs are by law instructed to maintain a sufficient preparedness level for their own activity. Oil companies operating on the Norwegian continental shelf have organized this through NOFO.

There are two *de facto* regimes for OSR in Norway:

1. if the spill results from a shipwrecking, NCA is in charge of the response;
2. if the spill comes from an oil installation, the oil companies through NOFO are responsible.

If the responsible actor, such as an IUA, is unable to handle the polluting event, NCA may assume control of the response.

The main OSR regulator is Klif. PSA's role is mainly preventing oil spills (barrier 0). Oversight is jointly handled by Klif, PSA, NMA and NCA.

2.3 The industry

This chapter provides an overview of the Norwegian OSR industry.

2.3.1 The companies

16 companies have been included in the overview of the Norwegian market. They have been surveyed on specific market- and company-related questions, e.g., R&D spending and international activity. The survey results will be mentioned below and discussed in chapter 6. Detailed information on each company is presented in Appendix 3, and survey results are summarized in Appendix 9.

Table 2 shows that nine out of 16 companies are producing equipment for mechanical recovery, while three are producing remote sensing equipment or other electronic utilities. Further are three companies active in operational services. Such services may include the tailoring of contingency planning for private companies, renting out personnel or equipment, training, and consulting services.

There is only one wholesaler, AllMaritim, which has exclusive distribution of Norén and NOFI oil booms. NOFI has a majority stake in the company and uses it as its primary sales channel.

As can be seen in figure 18, the companies are spread out all along the Norwegian coast. Some agglomerations do however appear in Bergen, the Oslo fjord area and in Lofoten & Vesterålen.

Company	Main product/business	Established
Aanderaa Data Instrument (Aadi)	Boom management systems	1975
AllMaritim AS	Wholesales	1988
Aptomar	Censors / Radar systems	2005
Arctic Protection	Operations	2005
Expandi	Booms	1970
Frank Mohn AS	Skimmers / Pumps	1938
H. Henriksen mek. Verksted AS	Skimmers	1856
Markleen	Booms / Skimmers / Pumps	1993
Miros AS	Radars	1984
MMB	Operations	1999
NOFI	Booms	1978
Norén	Skimmers	2002
NorLense	Booms	1975
NPS	Consulting	2006
Seaworks	Operations	1995
Skimmer Technology	Skimmers	1965

Table 2: List of 16 Norwegian OSR companies in the thesis. For more information on the companies, see Appendix 3.

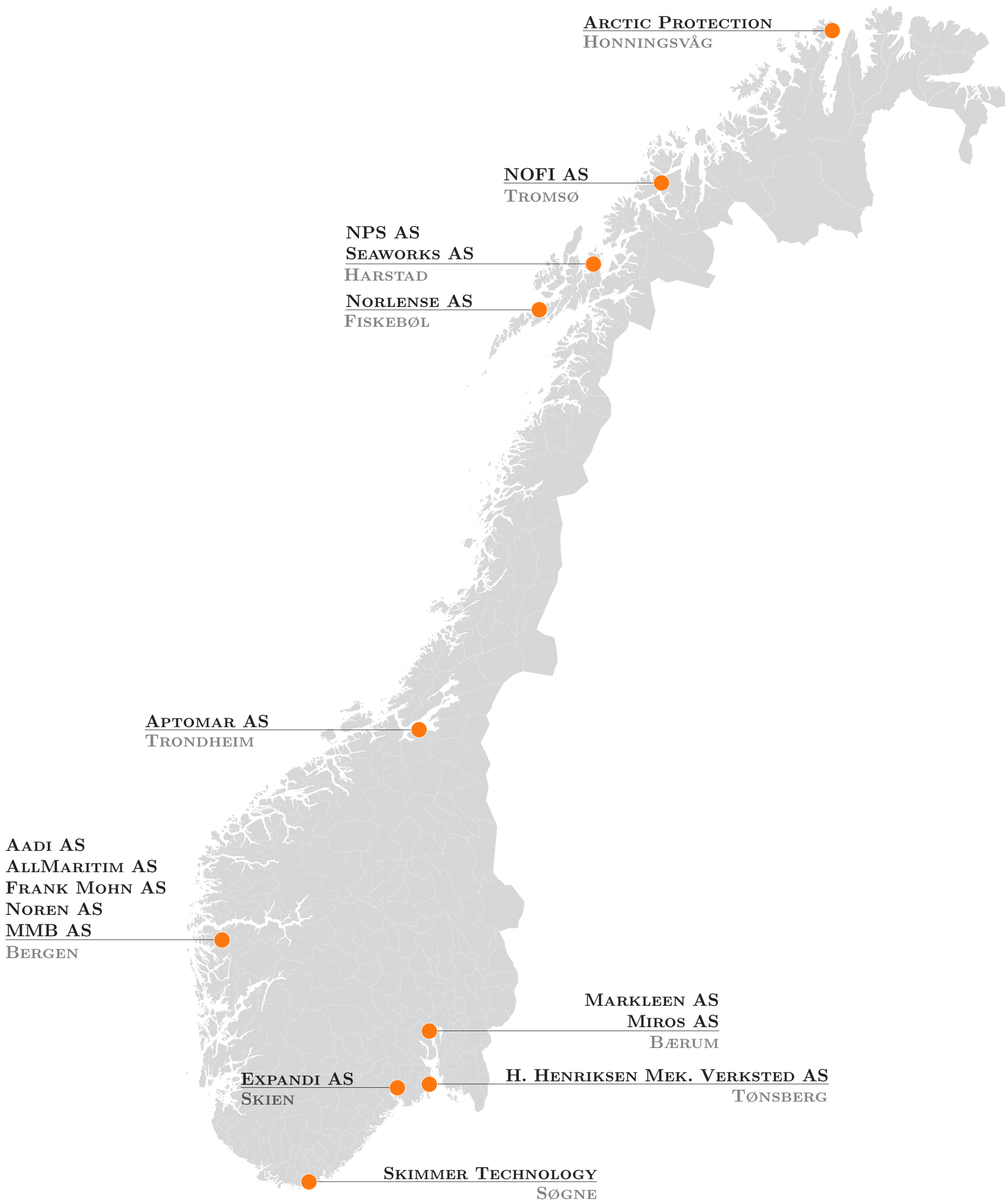


Figure 18: Map showing the location of 16 Norwegian OSR companies.

Company	Main business	Revenue (2010)	Business related to OSR	Revenue related to OSR (avg.)
Aadi	Production	152188.00	0-20%	15218.80
AllMaritim AS	Marketing/Sales	91850.00	80-100%	82665.00
Aptomar	Production	30849.00	80-100%	27764.10
Arctic Protection	Operations	2999.00	80-100%	2699.10
Expandi	Production	684.00	80-100%	615.60
Frank Mohn AS	Production	2732750.00	7-8%	204956.25
H. Henriksen	Production	53316.00	20-40%	15994.80
Markleen	Production	8459.00	80-100%	7613.10
Miros AS	Production	70496.00	20-40%	21148.80
MMB	Operations	13210.00	80-100%	11889.00
NOFI	Production	88195.00	40-60%	44097.50
Norén	Production	24439.00	99-100%	24316.81
NorLense	Production	69196.00	80-100%	62276.40
NPS	Consulting	954.00	80-100%	858.60
Seaworks	Operations	194725.00	1-3%	3894.50
Skimmer Tech	Production	1451.00	80-100%	1305.90
Sum		**3535761.00**		**527314.26**

*Table 3: Revenue related to oil spill response (2010) for Norwegian firms in OSR. Accounting info retrieved from the Ravninfo database. Revenue related to OSR = (Revenue*average(Business related to OSR)). The percentages under Business related to OSR are based on information given by each company*

The list presented in table 2 is not a complete list of Norwegian OSR companies. There are other companies in the business—some are mentioned at the bottom of the list—but the combined total OSR related income of these companies is expected to make up only a minor part of the total industry income. Also a big company like DNV, which are involved in OSR, is excluded because of the difficulties defining which part of the business that is OSR related. It should be noted that the calculations based on this list of companies are only estimates and may not be completely accurate.

There are also smaller start-ups in the market that have not been included in this list, mainly due to size. Examples are Coastsaver, Kaliber Industridesign, Abtek and Maritime Robotics AS.

2.3.2 Economic analysis of the supply industry

Through accounting numbers and surveys, it has been possible to identify the degree of internationalization, the importance of the OSR market for the companies and the typical size of an OSR company. All numbers analyzed is from 2010, and will therefore not reflect the most recent movements in the market.

Table 3 shows that, except for Frank Mohn, with oil spill related income of about 200 MNOK, most Norwegian companies have an estimated oil spill

Company	Main business	Profit (2010)	Revenue growth (2006-10)	Profit margin 2010
Aadi	Production	23587.00	13.7%	6.15
AllMaritim AS	Marketing/Sales	11285.00	256.0%	11.64
Aptomar	Production	-15012.00	2231.7%	-47.41
Arctic Protection	Operations	-4597.00	2399.2%	-137.98
Expandi	Production	495.00	302.4%	72.37
Frank Mohn AS	Production	1785850.00	-4.7%	9.08
H. Henriksen	Production	8275.00	33.8%	14.29
Markleen	Production	1190.00	-46.8%	14.02
Miros AS	Production	6987.00	103.5%	10.77
MMB	Operations	4865.00	30.8%	34.73
NOFI	Production	11146.00	46.7%	13.02
Norén	Production	6409.00	304.8%	24.63
NorLense	Production	2862.00	59.9%	3.99
NPS	Consulting	916.00	Too short history	59.85
Seaworks	Operations	2040.00	79.5%	2.90
Skimmer Tech	Production	560.00	Too short history	39.21

Table 4: Key numbers for Norwegian firms in OSR. Accounting info retrieved from the Ravninfo database. This table is not complete due to the lack of response from som informants.

related income between 10 and 80 MNOK. The rest are smaller companies with an oil spill related income under 8 MNOK. The four biggest actors on the Norwegian market—Frank Mohn, Nor-Lense, NOFI, and AllMaritim—make up almost 75% of the total income.

OSR is the main business area of more than half of the companies surveyed. 10 out of 16 companies asked say that more than 80% of the business is directly connected to OSR. Only three companies say that less than 20% is directly connected to OSR, Interestingly, Frank Mohn, with only 7-8% of their business connected to OSR, is the biggest actor on the OSR market and by far the biggest actor in total of the 16 companies examined.

The accounting numbers show a growth in the Norwegian market from 2006 to 2010. It is worth noticing that the numbers vary a lot between companies. Several companies have indicated an even higher growth in 2011 and 2012. Frank Mohn and Markleen are the only companies reporting a negative growth in the period 2006-2010.

When looking at the performance level of 2010, all but two of the 16 companies report a positive profit and a positive profit margin (table 4). The two companies reporting a negative profit and profit margin explain this with mergers/de-mergers (Arctic Protection) and high levels of venture capital (Aptomar). The latter expects to record a positive profit margin in

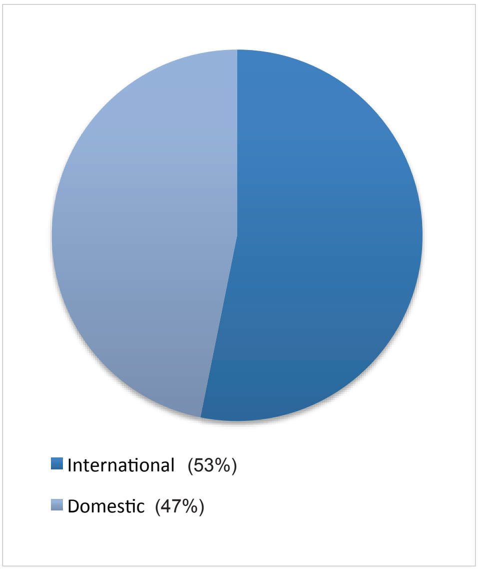


Figure 19: Total industry revenue related to international vs. domestic business. Based on numbers in Appendix 13.

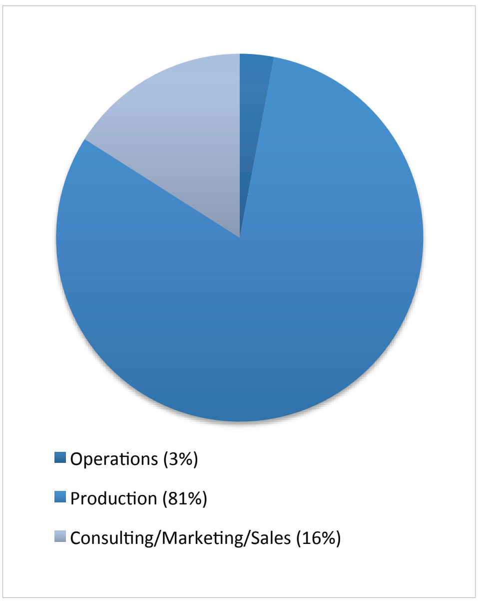


Figure 20: Total industry revenue related to business areas. Based on table 3.

2012. It may therefore seem that the Norwegian OSR market in general is both growing and profitable.

2.3.3 Internationalization

The combined business of all Norwegian OSR companies is distributed almost evenly between domestic and international business (figure 19). This indicates that most companies consider it to be important to be a part of both markets.

Of 11 responses on internationalization, six answer that international markets will be more important in the future, four answer that the relative importance between domestic and international markets will remain unchanged, while only one company answers that the domestic market will become more important. This is a clear indication that most companies are looking to move more of their business abroad. Offshore petroleum activity in Brazil and Africa seems to be especially attractive.

In summary, the companies in the industry are active mostly in equipment production, there are prospects of growth for the near future, and international markets are of increasing importance.

2.4 The market

This section will describe the structure of the Norwegian market for OSR products and services.

2.4.1 The sellers

The previous chapter summarized the Norwegian OSR industry (table 2). However, it should be mentioned that the Norwegian market also has a small number of foreign companies represented in the market. Lamor, the major such equipment producer in the world market, is one of them. These companies have not been included, as the focus of the analysis has been on Norwegian companies.

Of all sellers, the manufacturers make up more than 80% of the combined total revenue of the industry (figure 20). The only distributor, AllMaritim, totals 16 percent of total industry revenue. Few companies are active in operational services. Operations cover only 3% of industry revenue.

The functioning of the market is modeled in figure 21. This is a rather complex diagram that shows the flows of equipment and services between the major actors in the market. To the left are the producers of equipment and knowledge. In the middle are the service-oriented companies, in distribution and operations. Far right are the end users, the operational organizations of

FACTS // DNV aquires NPS

Although the Norwegian industry is heavily based on development and production of equipment, it should be noted that other actors might have an increasing interest in oil spill response. One such actor is Det Norske Veritas (DNV). They are running a joint project with Sintef on equipment certification, and such certification is expected to become an industry standard.

DNV is also seeking to ascertain their position as a leading competence actor in oil spill response. In April 2012, DNV acquired the consulting firm Norwegian Petro Services (NPS). The acquisition was described as important regarding DNV's arctic strategy, and NPS' competencies will be included in DNV's environmental risk planning. As figure 2.12, NPS is one of few actors in consulting in the industry.

FACTS // NOSCA

Nosca - The Norwegian Oil Spill Control Association - is an industry organization that was established in 1992 in order to improve the overall knowledge base of oil spill prevention and response. NOSCA promotes Norwegian oil spill technology and products internationally. It also sees itself as an active player in R&D, oil spill prevention and response. *(Source: Nosca 2012)*

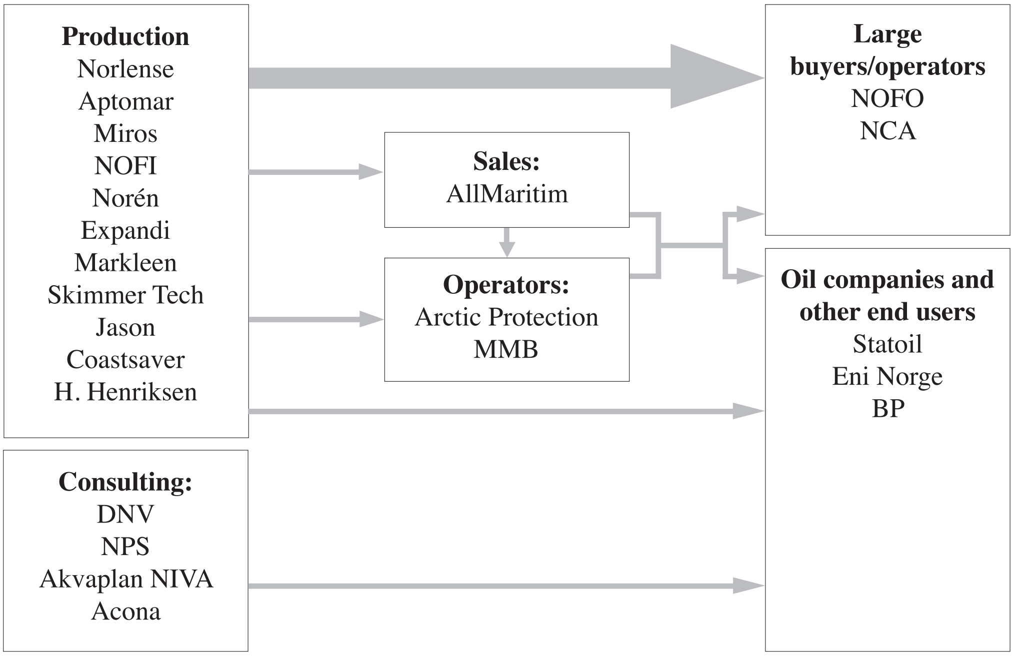


Figure 21: The interactions in the Norwegian OSR market.

NCA and NOFO, but also oil companies and other private actors. The latter two may buy consulting and/or operational services in addition to services provided by an actor such as NOFO. The thick arrow marks the major flow in the market, the sale of equipment from producers to the major buyers.

2.4.2 The end users

«Buyers» and «end users» are not really equivalent terms in this market. The main end users are the operating oil companies, which are responsible for maintaining OSR on the continental shelf, and the NCA.

The reason why «buyer» and «end user» is not necessarily equivalent, is that the end users of most of NOFO's equipment are the oil companies. NOFO maintains a certain level of preparedness for its member companies, and when an incident happens these are commanded by the responsible party, the oil company in charge.

An easier way of modeling the market is shown in figure 22. Instead of showing the specific interactions, it focuses on the main flow. The market

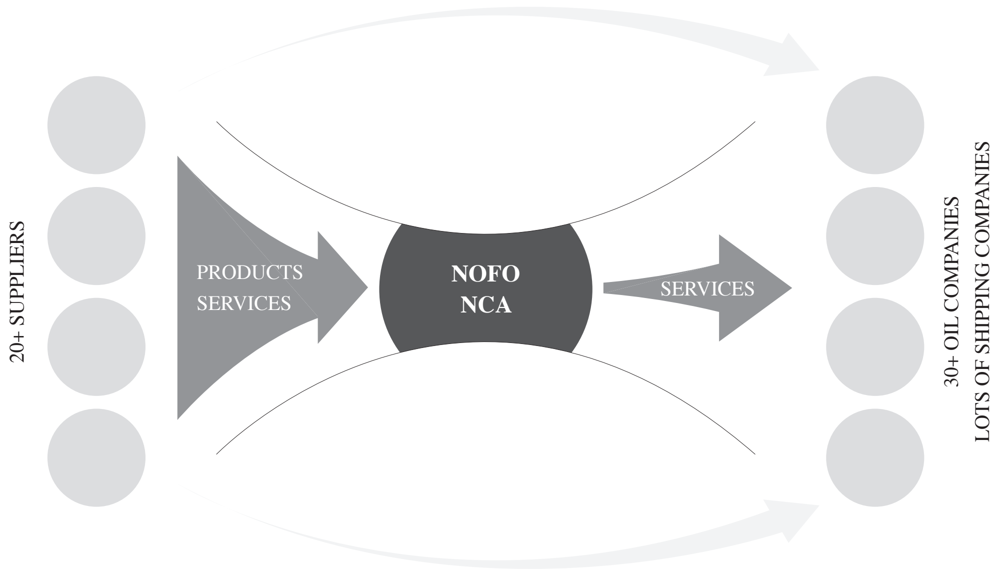


Figure 22: The functioning of the Norwegian OSR market.

consists of a handful of suppliers on the one side and a great number of users on the other, and in the middle are the two major buyers in the Norwegian market, NCA and NOFO. Most of the transactions in the market are «funneled» through these actors.

Therefore, most actors on the right in the model—IUAs, oil companies and other private companies—do not operate as independent buyers in the market. In IUAs, funding is an issue, as was mentioned in chapter 2.2.2. Where population density is low, the little funding that exists is channeled towards training of people in the area, and they rely on NCA to a larger extent for access to or funding of equipment. IUAs therefore rarely operate as independent buyers in the market.

The oil companies are not dependent on NOFO in the same way, they have sufficient funding for contingency equipment. But they have traditionally channeled their needs through NOFO, and are still doing so, due to perceived cost efficiencies. They are therefore also, for the most part, seen as indirect buyers rather than direct.

2.4.3 The buyers

The responsibilities of NCA and NOFO, the two major buyers in the market, were described in chapter 2.2. Here follows a description of their roles in the Norwegian market.

NCA

In the market for OSR equipment the NCA has several roles:

- Equipment buyer – as an emergency response organization
- Service producer – as a response coordinator and standards enforcer

NCA purchases equipment, normally in large quantities, for all 16 depots and occasionally (when funded) for IUAs. These contracts are normally sizeable and they are tender-based, as is standard government procedure.

Their purchases are based on gaps identified in the NCA Emergency Preparedness Analysis (EPA). This analysis is conducted every ten years, as a basis for the dimensioning of governmental OSR. The EPA does however not include considerations on further innovation in OSR products and services.

NCA is also an operational service producer. Examples of such services are courses and training, outfitting of vessels for OSR, and standardization management. NCA normally also produces its own concepts for emergency management.

NOFO

NOFO is the second major buyer in the market. NOFO maintains OSR equipment for all of its 30 member companies. It purchases for its five main depots and emergency vessels. Just as NCA, NOFO generally buys in large quantities.

As NCA, NOFO is also a service producer rather than service buyer. The organization buys equipment from producers in the market, but organizes the use of this equipment in-house. An example of this kind of service production is the ongoing set-up of a fleet of fishing boats in OSR. Operational services are rarely sold to NOFO. However, NOFO did recently contract out the setup of a coastal task force, which was done by Arctic Protection.

Others

The market outside of these two buyers has been marginal. Hydro, before the merger with Statoil, was also to some extent active in arranging their own OSR. Today, large terminals such as Statoil Sture and Statoil Mongstad have their own OSR and other companies are starting to set up more of their OSR on their own, going directly to market for their needs. An example here is the Goliat license partners ENI and Statoil, contracting consulting and operational activities with Norwegian Petro Services and Arctic Protection.

2.4.4 Economic perspective on the market

Worldwide OSR market

The OSR industry is a small industry. The total worldwide market size is estimated to be somewhere between 600 and 700 million Euros or approximately 5 billion NOK (Stephen Jewell, Regional Manager in Lamor, personal communication 15th March 2012). To put this in perspective, Statoil had a total income of 530 billion NOK in 2010. This implies that the combined total income of all OSR businesses is just over 1 percent of Statoil's total income. In other words, it is safe to assume that OSR is a small budget post for the major oil companies.

Norwegian OSR market

The total income of these Norwegian OSR companies in 2010 was somewhere between 450 MNOK and 600 MNOK (average value in table 3). This implies that Norwegian OSR companies makes up about 10 percent of the worldwide OSR market. It must be noted that all accounting numbers are from 2010 and that several companies indicate growth both in 2011 and 2012. Because of this the actual size of the Norwegian OSR industry may be larger.

2.5 Innovation and development

This chapter will briefly describe actors in and initiatives towards innovation in OSR.

2.5.1 Actors

The institutional structure of the Norwegian innovation system includes a whole set of actors. These are summed up in table 5.

In Norway, an integrated innovation policy was introduced in 2003, which was based on the theory of a national innovation system. Today, two of the most important actors in stimulating innovation are the governmental actors Research Council of Norway (RCN) and Innovation Norway.

Innovation Norway is «the Norwegian Government's most important instrument for innovation and development of Norwegian enterprises and industry» (Innovation Norway 2012). The organization provides competence in innovation, and advisory, promotional, and networking services. It has not been possible to assess the number of projects or amount of funding by Innovation Norway related to OSR due to categorization issues.

RCN is the official actor in the development and implementation of national research strategy. The organization works to enhance the Norwegian knowledge base to meet societal needs,

Function	Actors
Organizing and financing	The Research Council of Norway (RCN) Innovation Norway The ministries
Infrastructure	Statistics Norway Brønnøysundregistrene Libraries Patent offices, other databases Various supervisors
Executing R&D	Universities, business schools, colleges Research institutes (Sintef, FFI, IFE etc) Regional research institutes Private sector: Mainly large firms, also some activity in SMEs)
Technology diffusion	SIVA (innovation network) Technology transfer offices Technology guidance offices Research parks and knowledge parks Private sector: Consulting, other
Financing of risk capital	Innovation Norway Argentum fund Seed capital funds Private sector: Venture capital, banking

Table 5: The institutional structure of the Norwegian innovation system (SPILLING & ROSENBERG 2007:75).

through the promotion of basic and applied research and innovation. It supports three types of projects: researcher projects, knowledge-building projects with user involvement, and user-driven innovation projects. The percentage of private-sector funding differs from 0 percent in researcher projects to more than 50 percent in user-driven innovation projects.

There is a specific RCN research program, «Petromaks», directed towards the challenges in the oil and gas industry. Over the last decade (2002-2011), the program has supported 341 projects with a value of over 4000 MNOK, whereof half of these funds have been provided by Petromaks/RCN. The first RCN-supported project in OSR was started in 2008. Since then, a total of 8 projects have been supported, with a total RCN contribution of 36 MNOK. All projects had private-sector funding, none were funded as pure researcher projects (Andreas Q. Nielsen, personal communcation 8th May 2012).

The government and industry collaborate in defining what type of projects that should be supported. An important actor in this respect is OG21,

Oljevern 2010 (Norwegian comapnies)	Main product/business	Established
Aanderaa Data Instrument (Aadi)	Boom management systems	1975
Åkrehamn Trålbøteri	Oil recovery systems	1955
Aptomar (2 projects)	Censors / Radar systems	2005
Aranica AS	Remote sensing equipment	2009
CodarNor AS	Radars	2009
Frank Mohn AS	Skimmers / Pumps	1938
H. Henriksen mek. Verksted AS (2 projects)	Skimmers / Skimmer systems	1856
ISPAS AS	Radars	2001
Kaliber Industridesign AS	Beach clean-up	2010
Maritime Robotics	Remote sensing equipment	2002
MDGroup AS	Oil recovery systems	2009
Mercur Maritime	Beach clean-up	2002
Team Innovation Trondheim AS	Oil spill recovery robots	2008
Vacumkjempen Nord-Norge AS	Beach clean-up	1998

Table 6: Norwegian projects that were accepted for the NOFO program «Oljevern 2010».

a strategy group for the oil and gas industry that provides industry input to the national technology strategy and to some extent coordinates R&D in the industry. Their report no. 1 on Technology Target Areas (TTA) covers OSR. On this topic, a priority is «new solutions to detect, contain and clean up oil spills», ahead of improving existing systems (OG21 2011:20). Thus, there is an emphasis on developing completely new technology in this area.

2.5.2 Specific innovation programs

Innovation was formerly an activity run primarily by SFT, the government agency responsible for oil spill preparedness. The last government-run technology development program was completed in 1993.

Since then, there has been a shift to industry-run innovation in OSR. Governmental actors contribute knowledge and know-how, and some financial support through RCN and Innovation Norway, while the industry actors run the projects.

NOFO has taken over the role of innovator from the NCA, and is now running the technology development program «Oljevern 2010». This is the first major development program to be run since 1993. 20 projects were selected from 180 applications, in the areas of oil recovery at sea, dispersion technology, remote measurement technology, and technology for coastal and shoreline operations (table 6) (NOFO 2011b).

The budget for the program is 90 MNOK, of which NOFO and Innovation Norway have contributed 50 percent each. NOFO has committed an additional 60 MNOK to buy the first batch of all successful projects. It is described by NOFO as a very successful program (Sjur Knutsen, personal communication, 13th March 2012).

Apart from what may come out of this program, the industry has seen little revolutionary innovation in recent decades. Most of the innovation processes are improvement of existing products. 30 years ago, booms and skimmers were the major tools for oil spill recovery and they still are today.

In an attempt to quantify the state of innovation in the industry, a patent search was conducted on the specific technologies of OSR. This was carried out by Oslo Patent Office specifically for this thesis. The search turned out few patents—only 20 in total—with the earliest of these recorded in 1987. Remote sensing technologies were not included in this search. The patents are listed in Appendix 7.

Remote sensing technologies are an exception. These technologies have developed a lot in the last decades, and companies like Aptomar are combining new technology to create state-of-the-art products for the OSR industry. One of the main reasons that innovation and development occurs in this part of the industry is that these products can be sold in a much bigger market, including shipping and marine rescue (Stein Erik Sørstrøm, personal communication, 22nd March 2012).

2.5.3 Other innovation initiatives

There exists an initiative for a cluster development, Arena Beredskap, with the aim to support innovation in its member companies and increase their competitiveness nationally and internationally. Arena was initially established for companies in the value chain of Norlense, but has today developed to include many other firms, also firms that are direct competitors.

Opinions on the potential for the creation of an OSR cluster have been voiced, most notably by former deputy Secretary of Petroleum and Energy Hans Henrik Ramm. He has advocated the creation of such a cluster in Northern Norway, including the companies in northern Nordland and Troms, such as Norlense. According to a memo by Ramm, he is adament that this can only happen if there is a functional and open market.

There is another non-formal clustering of companies in this industry in the Bergen area. This group of companies comprises MMB, Norén, AllMaritim, Coastsaver, Aanderaa, and Frank Mohn. It is a group of quite complementary companies, and there is to a certain degree collaboration between some of the companies there.

2.6 Research summary

This chapter has presented an overview of the Norwegian OSR. Basic policy, a presentation of current OSR technology and a brief history was presented in order to understand the fundamentals Norwegian OSR. This was followed by a thorough description of the market, both the demand and the supply side. Chapter 2.5 focused on innovation and development in the Norwegian OSR market, which is a central topic in this thesis.

This chapter will along with the literature review (chapter 3) and the interviews (chapter 5) provide the basis for the discussion in chapter 6.

3 Literature review

Based on the research on Norwegian oil spill response (OSR), an appropriate theoretical framework has been set up. The two main components of this framework are innovation systems theory and buyer power theory. The following chapters will present this theoretical background.

3.1 A conceptual background of innovation

There is a bewildering number of definitions of *innovation*. A simple definition is «the successful exploitation of new ideas» (DTI 2006:9). According to Kline & Rosenberg (1986:275), «successful outcomes in innovation require the running of two gauntlets: the commercial and the technological». It has been established that there is both a technological and a commercial side of innovation, distinguishing it from pure invention.

Further, two basic distinctions are needed. First, innovation may be radical (disruptive) or incremental. The term «radical» has been associated with revolutionary innovation, while «incremental» is associated with improvements of existing technology. Second, there is a difference between product innovation and process innovation (figure 23). Innovation may be anything from the development of a new product, a process of production, a business model, some form of cost cutting—and each of these may be radical or incremental (Feldman 2000).

3.1.1 Innovation drivers

What drives innovation? The set of factors vary from case to case, and normally both internal and external innovation drivers exist.

Internal innovation drivers

Today, innovation is a main factor for a firm's competitiveness and is «perhaps essential for their survival» (Swann 2009). By innovating, a company can gain a competitive advantage over its competitors. The simple diagram in figure 23 describes how innovation improves competitiveness.

In this figure, the line from product A to product C shows the consumer's willingness to pay, where A is cheap and low quality, and C is expensive and high quality. Product B is neither cheapest nor has it the highest quality. But its competitiveness can be improved versus A and C by product innovation—better quality, same cost—or by process in-

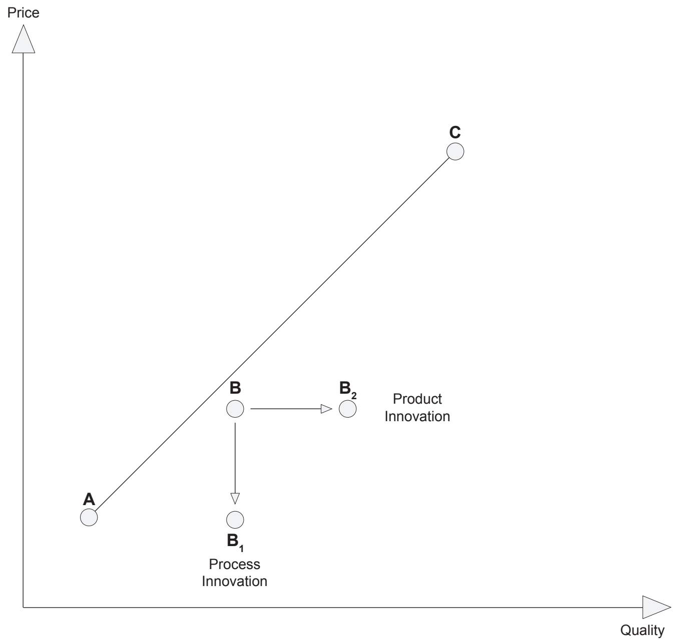


Figure 23: Comparing product and process innovation (SWANN 2009).

novation—same quality, lower cost—or both. So, while product innovation is conducted to increase the quality of a product, process innovation is often an important part of cost cutting.

All firms seek to internalize the benefits of innovation. In some cases innovators profit from their innovations, in some cases not. How the sharing of benefits of innovation is affected by market power and buyer power will be discussed later in this theory chapter.

External innovation drivers

Every innovation process has its own characteristics and drivers. Economists often analyze technological innovation as a «black box», a system with unknown components and processes (KLINE & ROSENBERG 1986). It is also a fact that most research has concentrated on the inputs and outputs of this box, but little research has been done on what actually happens inside the box.

In general, there are two external forces that affect innovation. The first is the market forces, such as income, prices and demographics. The second is the forces of progress on the scientific frontier, which lead to new products or improvement of old ones. Put differently, if an innovation is to have a serious economic impact, there must be a demand in the market for the product, and the product must match the tastes and needs of eventual users. It must also manage to do this according to given cost restrictions (Kline & Rosenberg 1986).

It is difficult to calculate the output of an innovation process. This in turn implies that there always is a risk investing in new innovative products. When the uncertainty of future profits is high, like in many innovation processes, the willingness to invest may be low.

In OSR a worthwhile task will be to determine which drivers of innovation are present. What do the drivers that are present communicate in terms of the state of the industry?

3.1.2 Innovation systems literature

In an effort of pinpointing the drivers of innovation, among other things, there has been an immense development in the field of innovation theory over the last 25 years.

Decades ago, innovation was mostly considered a linear process that considered R&D activities in the firm the most important driving force. Today, innovation is regarded non-linear and interdependent, with feedback loops and networks with stable relations allowing for common learning (Cooke & Morgan 1993; Asheim 1996). Institutions—which here refers to rules—reduce uncertainty, regulate conflict and cooperation and incentivize innovation (Edquist & Johnson 1997; Tödtling 1998). Governance of innovation is therefore seen as more complex than before, as local, national, and supranational actors are involved (Cooke *et al.* 1998). Innovation is understood not to be best performed in isolation; rather it is a process in which interaction between enterprises, and between enterprises and other organizations, is a key factor in bringing new products, processes or forms of organization into economic use (Mytelka 2000).

From these insights the innovation system approach has developed. The term *system of innovation* was first used by Freeman (1987:1), as «the network of [actors] in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies».

Since then, several branches of innovation system theory have developed, at different levels for different purposes of analysis. In *national innovation systems* (Lundvall 1992; Nelson 1992), the unit of analysis is the country, with actors and linkages both in the industry and at the government level. In *regional innovation systems* (Saxenian 1991; Tödtling & Trippl 2005), social networks and culture in the region is emphasized, while in *sectoral innovation systems* (Breschi & Malerba 1997; Malerba 2002) the focus is on firms in a specific sector. *Theory on technological innovation systems* (Carlsson & Stankiewicz 1991), which will be employed in this thesis, looks at the development and diffusion of technology.

It should be noted that the innovation system is primarily an analytical construct. It is a tool that is used to model and make sense of innovation as a larger concept. Using a system perspective does not imply that a system outright exists—interactions between companies may be weak, linkages may be unplanned and/or unintentional, and actors may not be aware of their attribution to such a system.

3.1.3 Criticism of innovation systems literature

The main focus of most of innovation systems literature has generally been the structural components, e.g, actors, infrastructure, interactions, and capabilities. By pointing to the existence or lack of certain components, one may be able to determine which functions are present in the system. But it is hard to judge how «good» a structural component is without knowing how it influences the innovation system. According to Bergek *et al.* (2008), «how do we know whether the existence of a particular actor or network is a strength or a weakness»? Is it, e.g., a source of synergy or group-think?

Johnson (2001:2) argued that it might «be useful to look beneath their surface» to determine if the different innovation system approaches were in agreement about what «happens» inside a system. The paper identified eight «functions», defined as contributions of components to the goal of the system. The conclusion was that there seemed «to be quite widely spread correspondence between different innovation system approaches with respect to the functions they identify» (Johnson 2001:15). This list of functions has since been revised, and seven such functions will be outlined in chapter 3.2.3.

A related criticism is on the structural component of actors. Even though their role in the TIS is recognized as crucial, TIS studies have lacked an explanation of the functioning of actors, i.e., why actors do or do not perform certain actions (Suurs 2009). One solution that has been proposed is the concept of the *prime mover*, defined as an actor that has the power to activate the TIS by itself (Jacobsson & Johnson 2000). As such, they may be important for policy actors to identify. This concept does however not seem to be widely used, and is not a recurring term in theoretical contributions to the TIS literature.

A third criticism towards innovation systems literature is that it does not provide practical guidelines for policy development. By focusing on market failure resulting from structural deficiencies, scholars have overlooked the system failure caused by other weaknesses, such as in functions.

Therefore, a scheme of analysis for technological innovation systems was developed by Bergek *et al.* (2008), allowing for the overall assessment of system performance and the identification of the factors affecting this performance. This scheme of analysis will provide a basis for the discussion of the technological innovation system of OSR in this thesis.

3.2 Technological innovation systems

To understand innovation in OSR, an innovation systems approach is natural. The delineation of the system is not a nation or a region, but rather an industry. It could be appropriate to approach the topic as a sectoral innovation system (SIS), defined as:

> *A set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products (*MALERBA *2002).*

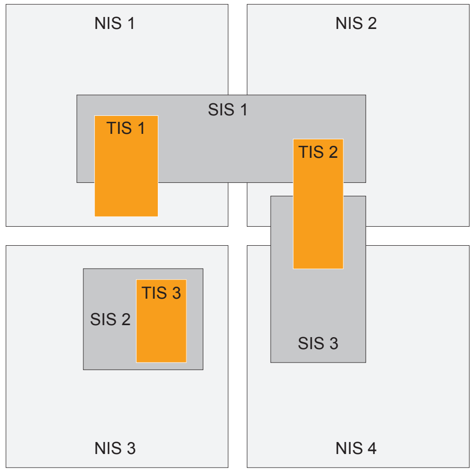


Figure 24: The levels of analysis of the NIS, SIS and TIS.

Another possibility is the approach of technological innovation system (TIS), defined as:

> *A dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology.* (CARLSSON & STANKIEWICZ 1991:93).

These approaches are obviously similar, differing mostly in their level of analysis (figure 24). A sectoral system is defined quite broadly, and may be seen as a collection of different but partially overlapping technological systems (HEKKERT *et al.* 2007; MARKARD & TRUFFER 2008). In a TIS, the definition of «technology» is narrower, e.g., a product or a knowledge field. It may be an aggregated product, where sub-products are complementary.

In this thesis, oil spill response can be defined as such an aggregated product, as the products and services involved are to a large extent complementary to each other (Staffan Jacobsson, personal communication, 30 April 2012). Also, as TIS analysis takes place at a lower level than SIS, it is considered better suited for an analysis of dynamics. Therefore, the TIS level is evaluated to be an appropriate level of analysis for this topic.

3.2.1 A primer on the technological innovation system

The starting point of an analysis through TIS is a technology or technology field, rather than a geographical area or industrial sector. The purpose is to evaluate the overall technological development by looking at the structural elements and processes that either induce or block it. Thus, it may be seen as a more micro-oriented SIS approach.

With this orientation, a distinct feature of the TIS has become the emphasis on utilization of technology. Carlsson and Stankiewicz (1991:112) wanted to «bring into focus the problem of adoption and utilization of technology as contrasted with that of generating and distributing knowledge» because «creating more knowledge within a nation or region may or may not result in improved economic performance». Another feature is a stronger focus on dynamics, as opposed to a purely structural approach. TIS dynamics have been researched by a number of scholars during the last decade (Johnson 2001; Carlsson *et al.* 2002; Hekkert *et al.* 2007, Bergek *et al.* 2008; Negro *et al.* 2008).

Underlying this technological system approach are four basic assumptions (Carlsson 1997): (1) the system is the unit of analysis, not the components; (2) systems are not static, but change over time; (3) technological opportunities on a global scale are almost unlimited, it is therefore impossible to identify them all; (4) actors are subject to bounded rationality, and their competence is stable and path dependent.

3.2.2 Structural components

The components of a TIS are similar to those in other innovation systems. They include actors, institutions, technologies, and relationships and networks.

Actors

The category of actors includes all organizations that influence the development of the technology in focus. In the TIS it is the actors that actually generate, diffuse, and use technology, and the build-up of the TIS is dependent on their actions (Suurs 2009).

The variety of potential actors is huge. They may be firms along the whole value chain, both up- and downstream, universities and research institutes, other public bodies, interest organizations, financers, standards organizations and so on.

Institutions

Institutions are commonly thought of as «the rules of the game», or «the humanly devised constraints that shape human interaction» (North 1990, in Suurs 2009). They can be formal or informal, where the former are enforced by an authority, and the latter are tacit, shaped by interactions of actors.

Examples of institutions are government laws and regulations, firm directives, norms and routines, culture et cetera. Alignment of institutions to the technology in question is always sought after. However, this is no easy process, as firms compete also over the nature of institutional setup. The institutions come in different forms, and influence in different ways. In some cases the lack of an institution may be of the most interest (Bergek *et al.* 2008).

When it comes to government intervention, institutions are usually the main target (Suurs 2009). The involvement of actors can typically only be affected indirectly, e.g., by tax incentives, support schemes et cetera.

Technologies

Technological factors are «artifacts and the technological infrastructures—which are themselves artifacts as well—in which they are integrated» (Suurs 2009:45). Techno-economic relations to these artifacts are also considered, such as cost structures, effects of scale, reliability et cetera. Knowledge and value chain characteristics are normally also included.

According to Suurs (2009), technological features have to a large extent been neglected by TIS researchers. This is due to the evolution of TIS out of the NIS tradition, where technological change was considered an outcome, rather than a determinant (Edquist *et al.* 2004).

Relationships and networks

Relationships may exist internally in each of the abovementioned categories. The actor-actor relationship is a relationship of actions, such as collaboration and transactions. This differs from the relations between technologies, and between institutions, which are relationships of design (Murmann & Frenken 2006). An analogy to such design relations is a system of laws, where one law is linked to the other. They may support (alignment) or contradict (misalignment) one another (Suurs 2009).

There also exist relationships between categories, such as actors-institutions and actors-technologies. These differ from actor-actor relationships in that they are not real interactions: The technological and institutional rules incentivize actions of actors, but the actions are always taken by the actors (Markard & Truffer 2008). Also, in these interactions actors may be in the position to change the rules, while in actor-actor relationships they cannot «change» each other, but have to work through the system.

A network may be defined when linkages between actors in a group are stronger than outside the group. These are forms of organization that enable knowledge exchange and common learning. According to Carlsson and Stankiewicz (1991:103), «there must be room for both positive and negative serendipity (unexpected discoveries), thus, the organization surrounding the search for information has to be flexible. This is where the notion of networks enters in».

Networks may be formal or informal. Formal networks can be specifically task-oriented, such as technology consortia, partnerships between public and private entities, standardization networks, or forms of supplier groupings. Other types may be less specific in their task orientation, such as university-industry networks or buyer-seller relationships (Bergek *et al.* 2008).

3.2.3 Key functions

There is a wealth of processes, or functions, mentioned in the literature on innovation systems and related work, such as socio-technical systems, development blocs, and industrial clusters. As mentioned above, a synthesis of these processes was developed by Johnson (2001). The list has since been subject to revision, and is expected to develop alongside increasing insight into the functioning of innovation systems.

Bergek *et al.* (2008) included insights from such fields as political science, the sociology of technology, and organization theory, and developed a widely cited list of seven key functions. These functions are listed below.

(F1) *Knowledge development and diffusion*

This function is at the heart of the TIS. It is concerned with the performance of the TIS in terms of its knowledge base, and the TIS's evolution. It also relates to the knowledge base of the technology globally. This function looks at both the breadth and the depth of the current knowledge base of the TIS and how these change over time.

(F2) *Influence on the direction of search*

The direction of search can relate to different things: technologies, applications, business models, markets et cetera. There are several factors that influence the direction of search in these areas. These may be expectations of growth, regulations and policy, demand from leading customers, technical bottlenecks, crises, or assessments of the relevance of knowledge and present and future technological opportunities.

A precondition for development of a TIS is that firms are incentivized to enter, and that they act upon these incentives. This is a major influence on the direction of search.

(F3) *Entrepreneurial experimentation*

Uncertainty is a common feature in any technological development, not only in the beginning but also in later phases. This is applicable also to the evolution of the TIS. Uncertainty can be handled, and reduced, by entrepreneurial experimentation, which entails trying out new technologies and applications. A social learning process will happen in this process of trial and failure. According to Bergek *et al.* (2008:416), «a TIS without vibrant experimentation will stagnate».

(F4) *Market formation*

In an emerging or transforming TIS, there may be a total lack of or an underdevelopment of markets. Other key factors such as marketplaces and clear demand articulation may also be lacking, and the new technology's price-performance may be poor.

Three phases are distinguished in the process of market formation. In the beginning, a «nursing» market must evolve, creating a learning space where a TIS may find its place. Although the extent of this market is limited, it may open for a «bridging» market, where the TIS can grow in terms of volume and number of actors. Finally, in a successful TIS, a mature market, or mass markets in terms of volume, may evolve. Such a market is characterized by stability in structures (regulatory and otherwise), technologies, and actors. Demand is clearly defined, and any uncertainties in the market are resolved (Bergek *et al.* 2008).

(F5) *Legitimation*

How appropriate and desirable is the new technology considered among relevant actors? This function relates to social acceptance and institutional compliance. It must both be accepted and comply with standards for demand to arise and thus for political power to arise for actors in the TIS.

Legitimacy is seen as a prerequisite for new industries to come into existence. It is not given, but «earned» or created through other legitimate actors that aid the TIS in overcoming the «liability of newness».

(F6) *Resource mobilization*

In the evolution of a TIS, there is a need for the mobilization of certain resources, such as human capital (through education in specific technological fields, also in management and entrepreneurship), financial capital (seed capital, venture capital), and complementary assets (complementary products, services, infrastructure). This is important to ensure further development of the TIS.

(F7) *Development of positive externalities*

Generating positive external economies, or free utilities, is necessary for the development of a TIS. External economies may develop from locational effects, such as pooled labor markets, easier access to goods and services by specialized providers, knowledge spillovers, and increased access to information.

New entrants may strengthen several functions in the TIS, and in the process create positive externalities for other members of the system.

3.2.4 Cumulative causation

Positive interactions between system functions are considered necessary for the emergence of a TIS (Suurs & Hekkert 2009). When functions fulfill each other, a virtuous cycle may occur (Jacobsson & Bergek 2004). Conversely, when one or more functions are not functioning well, a vicious cycle may occur. System functions are thus expected to reinforce or impair each other over time. This dynamic is aptly named *cumulative causation*. A variety of events and sequences result in either positive or negative development processes.

An example may start with positive results from a research project, which contributes to knowledge development (F1). This may increase expectations and experimentation (F3), inducing policy makers to influence the direction of search (F2), which in turn may result in resource mobilization (F6), inducing new activities contributing to knowledge development (F2) and so on (Suurs & Hekkert 2009).

Hekkert *et al.* (2007) identify three typical motors of change. Even though there are several more functions defined, they argue that possible starting points are fewer—developments often start in certain functions that further activate other functions. This dynamic is shown in figure 25.

An example is given for the case of sustainable technology (Hekkert *et al.*

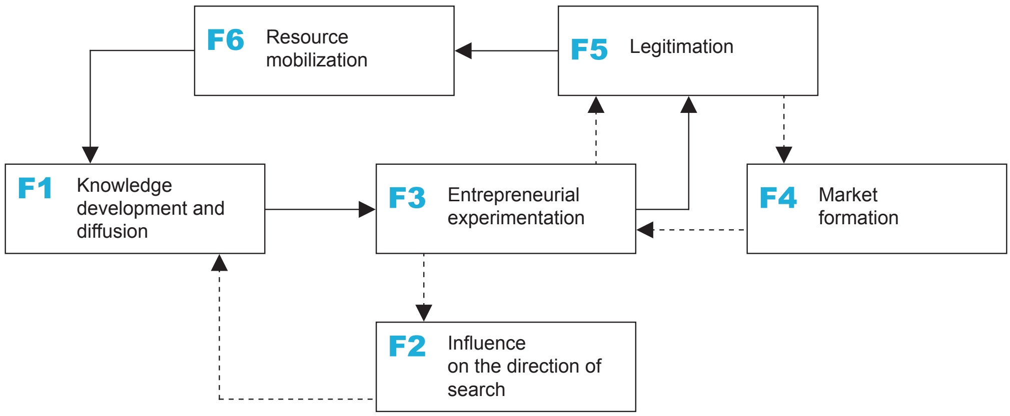


Figure 25: Possible interactions between system functions (NEGRO 2007).

2007). A common trigger is guidance of search (F2), where societal problems are identified, leading to knowledge development (F1) in the area, increasing expectations for further development, inducing entrepreneurial experimentation (F3). Two other motors stem from the entrepreneurs, who either lobby (via, e.g., advocacy groups in F5) for the formation of a market (F4) that does not exist, or lobby for resources that enable further knowledge creation.

3.2.5 INDUCEMENT AND BLOCKING MECHANISMS

Put another way, there are mechanisms that either induce or block functional development. These influencing factors are called *inducement mechanisms* if they improve the function, or *blocking mechanisms* if they stand in the way of improvement.

An example of an inducement function may be *belief in growth potential,* which may influence market formation, entrepreneurial experimentation, and the direction of search. Another example is a strong *R&D policy*, which may affect functions as knowledge development, resource mobilization, legitimation, and direction of search.

Blocking mechanisms may be *uncertainty of needs, inadequate knowledge of relations between investments and benefits, lack of standards, few university programs, and weak advocacy coalitions.*

These examples show that there may be a variety of factors that hinder functional development. According to Bergek *et al.* (2008:421), from a policy perspective «it is particularly important to understand the blocking mechanisms that shape the nature of the dynamics».

3.2.6 What can be learnt from innovation systems?

An analysis of a TIS will describe the actors in the system, how the system is working in terms of a set of functions, and the normative «goodness» of these functions. It will point to concrete mechanisms that induce or block the development of the system's key functions. As such, a TIS analysis is suited to develop perspectives on an innovation system for specific technologies, product fields, or products, which in turn can suggest key policy issues to be dealt with.

In the technological innovation system of OSR, how «good» can one assess the different functions to be, and which mechanisms either induce or block them? What kind of policies might relieve potential problems? Answers to these questions will be answered in chapter 6.

3.3 Buyer power

Now that the systems approach to innovation has been described, one can turn to more specific factors. As there are only two major buyers in the OSR market, the nature of this market merits a deeper look. How does buyer power in a market affect innovation?

A market is comprised of buyers and sellers of a specific good or service. The nature of this market is of importance for all firms operating in it, as sales, profits, and growth potential are functions of market conditions (Thompson & Formby 1993). It can take many forms: highly organized or not, efficient or inefficient, stable or volatile markets, buyer's or seller's markets, et cetera. When analyzing markets, perfect competition is often assumed. This is a market where:

- a large number of buyers deal with a large number of sellers, no one of which buys or sells more than an insignificant fraction of the total exchanged,
- the goods being offered by sellers are regarded by buyers as essentially identical,
- the only criterion for a transaction is that no better bargain is available (that is, no buyers have a loyalty or preference for dealing with a particular seller),
- all traders are aware of all offers and deals available (*ibid*).

In such a market both buyers and sellers are «price takers»—none of them have a strong influence on the market price. This is naturally not always the case, as there may exist few sellers or few buyers (or both), which in turn may appropriate market power. This will allow them to wield influence over the market.

Market power arises when there are a limited number of sellers. In a monopoly a single seller has strong bargaining power towards the buyers in the market. The monopoly represents the opposite of perfect competition. The oligopoly, a market with few sellers, is somewhere in between.

Buyer power arises when there are a limited number of buyers. A mirror image of the monopoly is the monopsony, a situation where there are many sellers and a single buyer, and therefore concentrated buyer power (OECD 2008). Likewise, the oligopsony is a market situation with only a few buyers. The next chapters will go more into detail on such buyer power.

3.3.1 Types of concentrated buyer power

Concentrated buyer power may be of two different types: monopsony power and bargaining power. A key difference exists in the execution of power—whereas monopsony power allows the buyer to achieve lower prices *in the act* of purchasing less, and thus lowering demand, bargaining power achieves lower prices *by the threat* of purchasing less.

Monopsony power

A buyer has monopsony power «if it can profitably reduce the price paid below competitive levels or its value of the marginal product» (OECD 2008:25). This situation arises when concentration on the buyer side of the market enables buyers to be «price makers». Less demand from the buyers will result in lower prices and vice versa. According to OECD (2008:10), «the key to identifying monopsony power in practice is recognizing that it is the existence of alternatives for sellers that determines the extent of a buyer's monopsony power».

A necessary condition for monopsony power to be executed profitably, is the existence of positive economic rents for the suppliers. In such a case, monopsony power transfers these rents to the buyer, maximizing monopsonist profit. Three types of rents may be involved:

Ricardian rents: Rent earned per unit is the difference between the price received and the marginal cost of supply. They exist when some factors of production are more productive than others. The suppliers earn the rent based on lower cost and higher productivity.

Quasi-rents: The difference between total revenue and short-run avoidable costs. The firm will stay in business in the short run even is the buyer extracts the quasi-rents, but in the long run the firm is expected to recover all of its costs, also sunk costs. The exploitation of these rents will in the long run drive the supplier out of business.

Monopoly rents: May be earned if the supplier has market power. The monopoly rent is the difference between total revenues and the opportunity cost of all production factors.

Bargaining power

The typical definition of bargaining power is «the strength of a buyer in its negotiations with sellers» (OECD 2008:37). It is applicable when buyer and seller meet in direct negotiations—typically in a market with few buyers and sellers in which buyer and seller negotiate on, e.g., conditions of supply and discounts. Differing from monopsony power, bargaining power does not drive down prices in the market in general by reducing orders, it achieves individual discounts by threatening to reduce orders. The goal is often rather to uphold or even increase orders, but at lower prices.

A caveat is in place here: Discounts awarded large buyers are not necessarily due to strong bargaining power, but may be due to efficiencies resulting from economies of scale (OECD 2008). In the following, the issue of bargaining power relates to non-cost-related discounts.

The implications of bargaining power, contra monopsony power, are different. Exploitation of bargaining power does not necessarily result in higher prices downstream, as the exercise of monopsony power usually does.

3.3.2 Sources of bargaining power

Setting aside monopsony power for the moment, where does bargaining power come from? An example showing how bargaining power depends on such factors as outside options, relative size, and information, is paraphrased in the example on the next page.

In this example, three sources of bargaining power are identified: the buyer's outside option, the seller's outside option, and bargaining effectiveness. These in turn depend on several factors.

Buyer's outside option depends positively on:

- Size of the buyer
- Competition upstream
- Relative size of the buyer and the supplier

Seller's outside option depends negatively on:

- Relative size of the buyer and the supplier
- Market power downstream
- Financial dependency

Bargaining effectiveness, which increases the outside option, depends on:

- Urgency (negative)
- Investment in reducing asymmetric information (positive)

3.3.3 Effects of buyer power

Certain general effects of buyer power on the market have been identified in literature. Monopsony power has adverse effects such as a sub-optimal level of trade and increased prices for customers downstream, while bargaining power has adverse effects such as increased prices for and decreased profits of competitors (OECD 2008).

In the OSR market, this does not apply directly, as the major buyers are not competitors and do not re-sell their purchased equipment. However, the effects indicate that strong buyer power may have a significant negative influence on the market. Effects of buyer power on innovation will be discussed in the following chapter.

EXAMPLE // Monopsony and buyer power

A downstream firm (the buyer) and an upstream firm (the seller) negotiate for the seller to provide the buyer with a good. The value to the buyer of obtaining it is equal to V. The cost to the seller of supplying it is equal to C. Joint profit equals therefore V-C.

The payment from buyer to seller is W. How should the surplus be divided—what value should W have?

If the seller has all the bargaining power, W=V-C, and the seller takes the whole surplus. If the buyer has all the bargaining power, W=C, and the buyer takes the whole surplus.

Suppose the trade was not made, the buyer may anticipate profits of V_B from another seller, and conversely the seller may suppose net profits of V_S from selling to another buyer. These are the outside options. Any lower V would result in non-agreement.

Hence, the surplus that can be realized is not V, but $V-V_B-V_S$. Bargaining effectiveness will determine how this surplus is split. If the buyer's share is λ, then the buyer's share of the surplus is $\lambda(V-V_B-V_S)$. The payment would be $W=(1-\lambda)(V-V_B)+\lambda V_S$. Profit would then be $V_B+\lambda(V-V_B-V_S)$.

From this one can conclude that «the greater the effectiveness of the buyer at bargaining (measured by λ), the larger its outside option, and the smaller the outside option of the seller, the smaller the W and the greater the share of the profits captured by the buyer».

(Source: OECD 2008: 37-38)

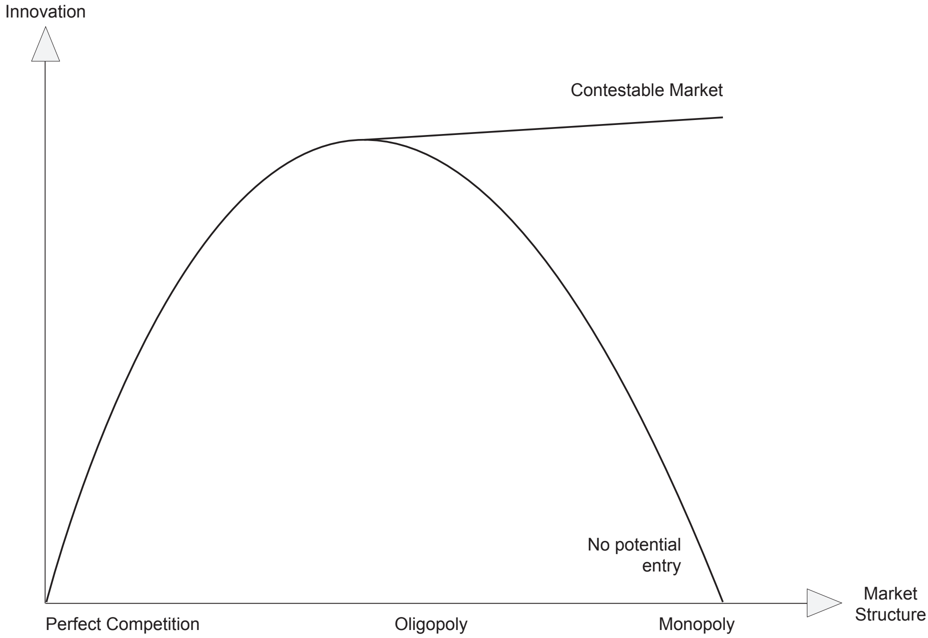


Figure 26: The relationship from market structure to innovation (Swann 2009:219).

3.3.4 Summary of buyer power

The research on the OSR market showed signs of buyer power. In this section the types and sources of buyer power have been established. In addition, some possible effects of buyer power have been mentioned. These are not directly applicable to the OSR market, but indicate an influence on the market.

3.4 Market structure effects on innovation

Will buyer power affect innovation? Most economists agree that there is a bilateral relation between innovation and market structure (Swann 2009). Different structures in the market will create different innovation patterns, and conversely it has also been established that innovation activities in firms affect the market structure.

3.4.1 Structure affecting innovation

There are two forces affecting innovation that differ depending on the market structure (Swann 2009). The first force is *incentive*: to what extent does a particular market structure incentivize a firm to innovate? The second force is *opportunity*: to what extent does a particular market structure give opportunity to innovate?

In a market with perfect competition, firms are not able to make above-average profits, which in turn holds back innovation. They would be incentivized to innovate if they see the potential of changing the market structure away from perfect competition—and gaining market power. But there is little opportunity financially to innovate under perfect competition, and therefore little innovation (Swann 2009).

> **EXAMPLE // The hold-up problem**
>
> The hold-up problem was demonstrated in a study of returns to an innovation in the tomato-processing market in Taiwan. It was shown that consumers did not benefit from innovation, and that the benefits to the farmers (sellers) were only 33 percent of what was estimated under perfect competition, while processing companies (buyers) captured the major share (Huang & Sexton 1996). Overall losses due to imperfect competition were an estimated 25 percent.

Regarding market (seller) power

In a monopoly, there is opportunity but there may be no incentive to innovate. Firms make above-average profits, which guarantees the opportunity. If there is a permanent monopoly, there is no incentive to innovate, as there are no competitors. On the other hand, if it is not a permanent monopoly and there is a potential of firm entry, the monopolist has a strong incentive to innovate, just to fend off competitors (Swann 2009).

In an oligopoly there is both opportunity and incentive. The oligopolists make above-average profits, though not as high as the monopolist, and there is competition on market share among the firms.

These arguments are summarized in figure 26. The extended line for the «contestable market» recognizes that a monopolist in a non-permanent market has even greater incentive to innovate than an oligopolist, as it has a greater market share to lose (incentive) and greater market power (opportunity) (Swann 2009).

Regarding buyer power

In a market characterized by strong buyer power, the seller may have neither a strong incentive nor opportunity to innovate. This is reffered to as «*the hold-up problem*» (OECD 2008).

When discussing monopsony power, it was noted that profitable exercise of monopsony power required capturing positive economic rents from the supplier. This is the source of the hold-up problem. If a seller anticipates that the buyer, due to its strong bargaining position, may be able to capture most or all of the gains from their bilateral trade, and especially if this in turn makes investment non-profitable, the seller may under-invest, i.e., create a hold-up in investment.

But another, more efficient outcome is possible: If the large buyer has an incentive not to be perceived as opportunistic, then it may be willing to bear some or all of the seller's investment costs.

Recent developments in theory also suggest that concentrated buyer power may have an adverse effect on product variety, reducing it to inefficient levels.

3.4.2 Innovation affecting structure

Structure affects innovation, but how does innovation affect market structure? Scholars disagree on this issue.

The «positive feedback» models argue that success breeds success, and that innovation therefore supports *industry concentration* (Swann 2009). Large firms may take advantage of scale economies in R&D, and retain higher profits for the further financing of such programs. A related hypothesis is that innovation builds market power, and that the opportunity of attaining a temporary monopoly position is one of the main reasons to innovate.

As such, «size and market power facilitate some aspects of (and components of) innovation, and innovation reinforces size and market power» (Swann 2009:223). Persistent dominance is argued also by several other strands of literature, e.g., *de facto* standards, pioneering brands, and R&D costs increasing with speed. It has been found that costly R&D acts as a deterrent, and that industry R&D intensity is positively correlated with the risk of failure for industry entrants (Swann 2009).

The opposite point of view has also been argued, that innovation supports *industry de-concentration*. Geroski (1990 in *ibid*) concluded with this in two studies of 73 UK industries in the period 1970-79. Gort and Klepper (1982 in *ibid*) argued that new entrants would produce major innovations, normally in the early part of the product life cycle (in the preparadigmatic phase, see figure 27), while incumbents would introduce incremental innovations throughout the cycle.

Also related to this, «*organizational inertia*» raises the issue that radical innovation may be increasingly difficult to exploit the larger a firm is. This may be rooted in the structure of the company, and issues like sunk costs, information

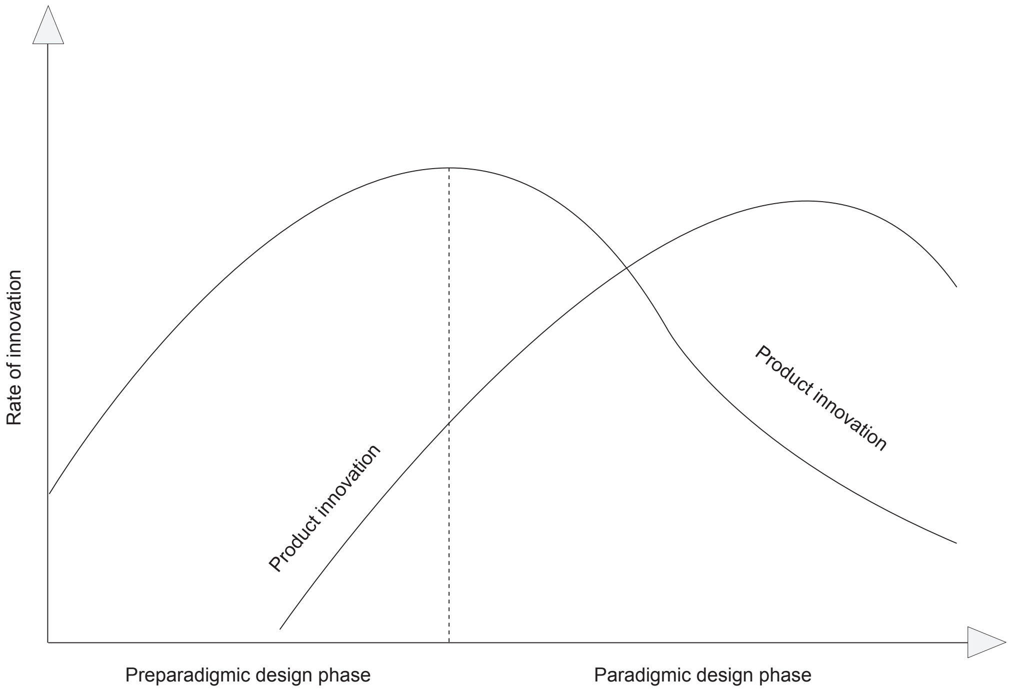


Figure 27: Product and process innovation related to the establishment of a dominant design (the dotted line) (TEECE 1986).

asymmetries, standards of procedure and such. Therefore, there may be major opportunities to be exploited by smaller firms (SWANN 2009).

The issues brought to light in this section reveal that there may be a link between the OSR market structure and innovation in OSR. How will the market structure for these products and services influence innovation in the industry? And does innovation influence the market structure?

3.5 The government role in innovation

Innovation is enveloped in uncertainty—when it comes to what drives it, how it is best performed, and how it affects certain conditions such as market structure. How can then the government get involved in innovation, and why should it? This question is answered in many different ways by leading scholars on innovation.

According to Edquist *et al.* (2004), innovation policy plays a role in industrial dialogue, especially in reducing coordination costs between producers and users. Porter (2000:26) adds «facilitating cluster development and upgrading» to a list of basic government roles in an economy, ascertaining that innovation is best supported indirectly. Carlsson (2006) argues that successful public policy aims to remove systemic obstacles and correct system failures. He also warns that too specific policies carry risks, such as lock-in, and that the existence of a certain need does not in itself require government involvement—as other actors may be able to fulfill this need.

Two major roles can be identified from literature (Kemp 2000; Porter 2000; Carlsson 2006): to provide 1) support through, e.g., subsidies or public research institutes, and 2) regulation. While the first role is direct facilitation or intervention, the second is an indirect means of stimulation.

What should the subsidies or regulations be aimed at? Bergek *et al.* (2008:423) argues that «policy should aim at remedying poor functionality in relevant TISs by strengthening/adding inducement mechanisms and weakening/removing blocking mechanisms». These mechanisms—the basis for such policies—can be identified through a TIS analysis. By doing so, the traditional perspective of «market failure» is substituted for the perspective of «system failure», focusing on functional weaknesses rather than structural inadequacies.

However, a criticism towards public policy is that the policies that would be effective are either too painful to implement or require too much patience from politicians (Porter 1990). As Carlsson (2006) questions one can shape policy «when the desirable outcome lies decades down the road and cannot be specified?» Another criticism brought forward is the lack of stringency in regulation. Stringency is necessary to promote radical technology response (Kemp 2000). Regulation that is not stringent does not encourage radical change, and subsequently, due to financial pressures, incremental innovation is the result, as a kind of «path of least resistance» (Hall & Kerr 2003:470).

The first criticism is hard to address from any theoretical standpoint. The second criticism might be addressed by the mechanisms relating to the functions of *direction of search* and *legitimation*.

For OSR, this means that public policy should evaluate the functions and their inducement and blocking mechanisms, and shape policy from the key issues that arise from the analysis.

3.6 Summary and expectations

In this chapter, theory on innovation systems and markets has been discussed. In addition, the government's role in encouraging innovation has been outlined.

How will this apply to the technological innovation system for OSR products and services? With the extensive research on this industry, some expectations for this TIS can be hypothesized.

There are seven functions outlined in this chapter: Knowledge development and diffusion, influence on the direction of search, entrepreneurial experimentation, market formation, legitimation, resource mobilization, and development of positive externalities. It is expected that the functions differ in their influence on the TIS.

These functions are the direct input for the first two expectations. The expectations 3-7 are based on issues discovered in the research of the industry presented in chapter 2, but these issues will also be discussed in relation to the TIS functions.

EXPECTATION 1: *Functions that affect the TIS positively are* ***influence on the direction of search***, ***legitimation***, *and* ***resource mobilization***.

It is expected that these three functions are fulfilled structurally, and that the structural elements involved contribute positively. There are strong competence environments both in NCA and NOFO, and in other environments such as Sintef and DNV, that both influence the direction of search and provide legitimation for the technology. Resources are available from a variety of actors, both in the response industry, in the oil industry, and from specific government programs.

EXPECTATION 2: *Functions that affect the TIS negatively are* ***knowledge development and diffusion***, ***entrepreneurial experimentation***, ***market formation***, *and* ***development of positive externalities***.

It is expected that these four functions either are not fulfilled or do not function properly. Innovation in the industry is to a large extent incremental, pointing to problems in knowledge development and may be a result of low entrepreneurial experimentation. Market formation lags in the market of services, which is almost internalized in NCA and NOFO. Positive externalities develop when other functions work well, which is expected not to be the case.

EXPECTATION 3: *Macro-level features of OSR contribute to innovation positively.*

OSR is a task of national importance. It is a part of the national system of emergency preparedness, and is supported by a number of governmental organizations.

It is also a part of a specific petroleum-related research program, Petromaks, run by the Research Council of Norway, and is a prioritized issue in the target areas for development specified by the oil industry organization OG21. Stakeholders in the industry, such as buyers and financial contributors, are resourceful in knowledge and finances. Also, there have been a number of incidents over the last decade that have revealed the need for a strong OSR. These are all macro-level factors that are expected to affect innovation positively.

Expectation 4: *Government regulation and support schemes contribute to OSR innovation positively.*

Regulation and support schemes are the two main ways the government can affect innovation. Both of these elements are found in the OSR system. The government poses regulatory OSR requirements through a number of organizations, such as Klif, PSA, and NMA. Governmental support for OSR development is handled through RCN, in the special research program Petromaks. These factors are expected to have a positive effect on innovation.

Expectation 5: *The concentrated buyer power limits the sellers' contribution to innovation.*

The research shows that there are two major buyers in the market, NCA and NOFO. In their position they may be able to build and exploit a considerable amount of bargaining power towards the sellers of response products and services. A possible result of this market structure is a hold-up problem—that sellers underinvest in innovation, as the benefits from such innovation will be captured by the buyers. Even if there is opportunity to innovate, there may be no incentive to do so. It is expected that such bargaining power has a negative effect on innovation.

Expectation 6: *The funding of the buyers limits the buyers' contribution to innovation.*

The research shows that IUAs in sparsely populated areas around the country will have a funding problem, as the financial resources are based on the area's population. Also, NCA has a low base funding for investment, which is determined by the Parliament. NOFO is backed by the financially strong oil companies. Still, it is reasonable to expect that OSR is not a main priority in the technological development and that is strongly cost-sensitive. Therefore, it is anticipated that the funding schemes have a negative effect on innovation.

Expectation 7: *Opportunities in the OSR industry remain in equipment production.*

Although few firms active in consulting and operational services, the greater opportunities still seem to be found in product development. If there are no changes made to the market structure, NOFO and NCA will probably continue to produce their own operational services and concepts, limiting the potential in this market. In the market for OSR equipment, there may be opportunities in dispersion systems, which is now to be phased into the Norwegian system. The remote sensing equipment niche is also in rapid growth, and may see increasing opportunities in the future.

To what level each of these expectations is fullfilled, and how well they are working will be thoroughly discussed in chapter 6.

4 Methodology

The research done in this report is conducted in accordance with guiding principles for case study research. Yin (2008) has been the main reference in this work, as it is seen as the foremost publication on such research.

4.1 Case study research

The study has been conducted as a case study on the OSR industry in Norway. According to Wacker (1998:375), the purpose of a case study is «to develop insightful relationships within a limited set of [actors]» by «empirically investigating individual cases for an in-depth understanding of the complex external world». Case studies are normally used when one investigates «a contemporary phenomenon in a real-life context» (Yin 2008:2), where the investigator has no control over the chain of events. It is also a characteristic for case studies that variables are many and data points few.

In such a way, the research for this report fits quite nicely into the case study category. The actors defined in the report are the sellers of equipment and services, and the main buyers. The development of the Norwegian OSR is most certainly a contemporary phenomenon that the authors' have no influence on. On this subject, alternatives to the case study are few.

4.2 Data collection

The sources for the research in this report are:

- Scientific publications
- Industry trade show
- Publications by OSR organizations
- Media
- Conducted interviews
- Survey

The three main sources of evidence are interviews, documents, and a survey. These will be further discussed in the following sections.

4.2.1 Interviews

Interviews have been a central part of the research for this report. It was important to come in contact with people who were or had been insiders in the system, and could provide relevant and concrete information to specific questions. This has provided the report with valuable information not obtainable otherwise.

The ideal selection of interviewees was:

- Several representatives from the industry, either CEOs or other top-level management. One senior person from the major buyer NCA. One senior person from the major buyer NOFO.
- One or several senior person(s) working with OSR in an oil company.
- One or several senior researcher(s) working with OSR in a research institution.
- One senior person from a technology mediating organization.
- One senior person working on policy issues.

An expected total of 15 shorter and longer interviews would cover the most important actors involved in OSR. It was assumed that this selection would provide both comprehensive and accurate information on the present-day situation and challenges ahead.

In the end, 9 formal interviews and 25 informal interviews were conducted, totaling 34 first-hand sources. The number of interviewees per employment category is shown in figure 28. The formal interviews probed a bit deeper into the overall subject matter, while the shorter, less formal, and relatively unstructured interviews regarded a single company and their views on the market. Also later interviews went deeper into the matter than the former. This reflects better knowledge on the interviewer's side and increased familiarity both with the interview situation and the issues discussed.

Some of the interviewees were found by web search, such as the researchers, the technology mediators, and some of the representatives from the industry. In addition, participation at the OSR trade show «Interspill 2012» provided a number of contacts, both in the industry, at NCA, and at NOFO. Further contacts, such as senior persons in the oil industry, were recommended by these. There were no close personal relations between interviewers and interviewees.

Some of the issues discussed in the interviews elicited somewhat emotional reactions from particular interviewees. Certain responses may have been colored by the lack of debate on the conditions of the industry and the market situation. There were also some negative characterizations of other parties to the process. The authors have made an effort to go beyond any façades.

Also, some information was given under the condition of anonymity, or retracted after the interview. The reason stated for this was that the interviewees did not want to jeopardize the relations to their buyers by publicly criticizing them. The information given under anonymity has been sought verified by other sources.

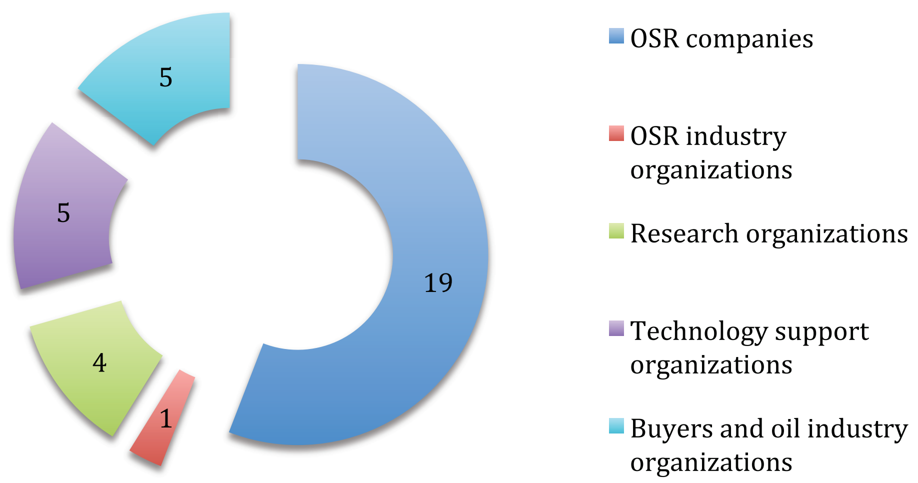


Figure 28: Interviewees distributed by employment.

Formal interviews

All formal interviews were conducted by phone, except two. This strategy was chosen due to budget and time limits. Interviews are normally preferred to do in person, and as some of the issues discussed are sensitive, in-person interviews might have enabled more in-depth questioning. However, this is presumed not to have important consequences for the validity of the report.

All formal interviews employed a semi-structured approach, with an interview guide for the general questions. This allowed the interviewer to keep track of the most important questions and at the same time gave the opportunity to follow up interesting trains of thought beyond the specified questions. This was seen as the best approach to the complex issues covered in this report.

During the interview, one of the authors acted as the interviewer while the other took notes. Formal interviews were also recorded, and transcribed after each interview. The notes taken could then be compared to the transcription, to prevent misunderstanding. All interviews were emailed back to the interviewee for fact checking.

Analysis of the interviews was done after transcription. One of the authors did the main text analysis for all interviews to avoid inconsistency. This should increase reliability but may also be a source of recurring errors. As interviews have been reread by both authors and the interview subject, the quality of this work has been verified.

Informal interviews

All informal interviews were conducted in person at the Interspill trade show. This was a great opportunity to meet most of the industry actors, see their products and discuss the framework conditions for their work. The interviews were unstructured, allowing the interviewees to bring up the topics that were most important to them. It also made it possible for the interviewer to quickly gather a variety of information on the industry and the market, gaining a broad understanding of the issues rather effectively.

The interviews were not recorded, but extensive note taking was possible as both interviewers were present. Still, there was a possibility that some notes were not accurate, either due to misunderstanding, noise in the trade show hall, or other factors. Therefore, the information from these interviews has as far as possible been corroborated by the same source again or other sources.

It is the authors' point of view that these interviews provided vital information to this thesis. The informality of the situation allowed interviewees to talk more freely than on tape, and express concerns that might not have been brought up in another setting. In return, such interviews must be subject to rigorous fact checking, which has been conducted to the best of the authors' knowledge.

4.2.2 Documents

Chapters 1, 2, and 3 are to a large extent based on document sources. Examples of documents used are general journal papers on technological innovation systems, research papers on OSR technology, energy research by the IEA World Energy Outlook, and published accounting numbers for the companies. The authors have as far as possible confirm the reliability and objectivity of sources used, mainly by ascertaining their origin at a credible and relatively non-biased source. Further sources were then derived from these initial sources. The documents that have been used in this report have been evaluated and are seen as reliable.

In the literature review, there has been a conscious effort to distinguish the highest regarded authors on the subject, verified by article citation count. Bergek *et al.* (2008) is one of the most cited articles on technological innovation systems. Journal databases and reference lists in articles have been helpful in this effort.

Documents related to theory development have in general been searched for in databases such as Scopus, Sciencedirect and ProQuest. Governmental documents have been downloaded directly from governmental websites and are consequently judged to be reliable. Other documents have been as far as possible been judged by the quality of their source.

4.2.3 Survey

Before the Interspill trade show, a simple questionnaire was put together. This was split in two parts, with one page covering the company and one page covering the market. Relevant questions on the company were the primary business area, internationalization, R&D, and customers. The part on the market was based on different word associations and statements, with which the respondent could disagree completely, disagree somewhat, be indifferent, agree somewhat, or agree completely. The survey is included in Appendix 8.

There were 11 respondents to the survey. This was satisfactory for the survey's purpose, as the data was not gathered for use in quantitative measures, but to generate a quick and reasonable overview of certain company information and attitudes. Thus, the survey data was not the basis of a quantitative exploration, rather a supplement in the qualitative approach taken overall.

This simple survey rendered invaluable information for the thesis, both on the companies and on the market. As an example, it quickly became clear that companies on the «inside» of the market were far more positive to the state of the market than were companies on the «outside». Aggregated respones to the survey are included in Appendix 9.

The information from the surveys was not complete. There were some answers missing in the filled-out surveys, which were not possible to get from the companies. An example is the table in Appendix 13. However, as the data is not gathered for use in quantitative measures, the data that were supplied still give useful insights.

4.3 Discussion of methodological issues

In all case studies, there are numerous pitfalls regarding methodology. It has been attempted to address these. Central quality measures in research are construct validity, internal validity, external validity, and reliability.

Construct validity is defined by Yin (2008: 40) as «identifying correct operational measures for the concepts being studied». This thesis attempts to shed to light on the factors that influence innovation in the OSR market. Measures that relate to innovation are many, e.g., patenting frequency, and new firm foundation. The concept of bargaining power has also been thoroughly discussed in literature. Indicative measures of such market power are the number of buyers, and the size of these buyers relative to the sellers.

This issue has been addressed by using multiple sources of evidence in data collection. This report is based on three sources of evidence: extensive documentation, extensive interviews, and a simple survey. From this comes an opportunity to verify the evidence presented. Information from documents have as best possible been attempted verified or disproved in the interviews. Information from interviews have as best possible been attempted verified or disproved in other interviews, especially with the aid of the interviewees «outside» of the OSR industry. In addition, the survey was based on concepts and issues that have been identified in documents and interviews. Ensuring such triangulation of data secures construct validity, and is a strategy proposed by Yin (2008). Another such strategy is establishing a chain of evidence through the report. Evidence presented in the discussion of this report is to some extent traceable in the interview section, and is related to the theoretical propositions in the theory chapter. However, anonymizing some information does weaken the chain of evidence.

Internal validity is defined as «seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships» (Yin 2008:40). The main way this issue is addressed is by making clear throughout the report how the specific inferences are made. The inferences are in general made on a basis of theory, research and/or interviews. In addition, the use of multiple sources of evidence, and a whole array of interviewees with different backgrounds, should also strengthen the validity.

External validity is «defining the domain to which a study's findings can be generalized» (Yin 2008:40). It is assumed by a strong grounding of the study in theory. Concepts and relationships are well defined in existing literature on which this study is based. Where there were definitions that differed in literature, specific comments have been made. One such definition is whether institutions refers to physical actors or rather the «rules of the game». In this thesis, the latter was chosen. Another issue that strengthens the external validity is the feedback from respondents on the interviews. Mostly minor changes were made to the text, and they were able to corroborate the information that had been discussed in the interviews.

Usually, the external validity is not very strong for a case study like this. As this is a single-case study, the findings will not be analytically generalizable.

Generalizability is also hindered by the special features of the OSR industry and market, such as the fact that most private buyers organize, purchases through a single association. But the case can no less provide a new perspective and suggest implications for theory. These suggestions must in turn be tested and verified.

Reliability is defined as «demonstrating that the operations of a study can be repeated, with the same results» (Yin 2008:40). To address reliability issues, interviews and documentation have been gathered in a Case Study Database. Some of this evidence is presented in full length in the Appendix for contextual matters. Unfortunately, interviews cannot be made available in full due to confidentiality agreements. For the same reason, the full list of interviewees is also withheld. These factors reduce the possibility of accurately repeating the case study, and in turn weaken reliability. However, the distribution of interviewees per employment category has been included (figure 28) to document the breadth of sources that has contributed to the research for this thesis.

4.4 Possible improvements

Interviews have been a central part of this study. With better planning, more of these could have been conducted in person rather than on the phone. This might have increased the quality of the interviews. Also, although a satisfactory number of sources were interviewed, more of these interviews could have been extended to formal interviews. This setting might have revealed more important information. Also, a politician and other industry and non-industry participants could have provided other points of view that have not become apparent in this thesis.

Another improvement would be an increased degree of fact checking towards the end of the report. Further follow-up conversations with the interviewees would be of value, as they would provide the opportunity for feedback and additional information.

5 Interviews

In the research for this report, the authors have spoken with a number of different sources. The formal interviews will be presented in this chapter in the form of a synopsis. Information considered as pure facts is used in chapter 2, while subjective information and market assessments are presented in this chapter. Full-length transcripts are not made available due to anonymity issues.

10 interviewees (9 interviews) have provided in-depth interviews for this thesis. In addition, a number of people have provided information for this thesis through conversations or informal interviews. These are employed in the OSR industry, in industry organizations, in research organization, in technology support organizations, or in the buyer organizations. The number of interviewees per category is shown in figure 28 in chapter 4.

LIST // Interviewees

Odd Gunnar Jørgensen, Chief of sales at MMB

Erik Sandsdalen, CEO of Miros and boardmember of NOSCA

Stein Thorbjørnsen, CEO at Norwegian Petro Services

Harald Karlstrøm, Managing Director at Arctic Protection

Ole Hansen, OSR advisor, ENI Norge

Frode Engen, OSR advisor, Statoil

Trond Mauritzen, CFO of NOFO

Steinar Lodve Gyltnes, Head of Department of Logistics and Technology, NCA

Stein Erik Sørstrøm, Research Manager at Sintef and Program Manager for the JIP «Oil in ice» and **Ivar Singsaas,** Research Manager at Sintef

5.1 OSR companies

5.1.2 Maritim Miljø Beredskap (MMB)

Interviewee: **Odd Gunnar Jørgensen (Chief of Sales)**
Date of interview: **17th February 2012, 13th March 2012**
Location: **Phone interview, and conversation at Interspill 2012**

MMB's business idea is based on heavy OSR equipment rental and education and training connected to this equipment. MMB's range of equipment includes several types of booms and skimmers. When expanding their range it is based on market demand, but because it is very capital intensive to invest in OSR equipment MMB also tries to predict what is needed in the future in order to be prepared. MMB's biggest customers in Norway are NOFO and Statoil, but Statoil channels most of its OSR through NOFO. Internationally Statoil is more important because NOFO only has a mandate on the Norwegian continental shelf, and MMB benefits from its connection to Statoil in the Norwegian market. Brazil, Venezuela, Tanzania and the Mediterranean Sea are ale important markets for MMB. Jørgensen also states that MMB is looking to expand their product range with services that are close to what they do today, but not necessarily in the OSR market. He believes that it is important to be diversified because the OSR market are very sensitive to shifts in the economic situation. In an economic slump, new exploration is postponed, eliminating parts of the OSR demand.

Jørgensen makes it clear that NCA and NOFO are the two locomotives in Norwegian OSR. They are very dominating as a customer and in setting the terms of supply. Every supplier that wants to operate on the Norwegian OSR market must deal with these two in a good way. Jørgensen admit that MMB has taken the consequence of this and tries to be on good terms with NCA and NOFO. He also emphasizes that international markets is getting more and more important, and that MMB depends on doing business abroad.

«OSR is an expense. OSR is a cost», states Jørgensen. He believes that companies buying OSR equipment and services see it as a cost they want to reduce as much as possible. He reminds himself that his customers want to use as little money as possible on the products MMB sells, and believes that this is probably something that is reflected in the degree of innovation in the market.

Jørgensen stresses that OSR is defined by external influence from authorities that create a set of rules. He believes that most oil companies adjust their oil spill preparedness to each country's regulation in order not to spend more money than they have to. At the same time companies like BP have experienced massive expenses after the Macondo oil spill, and this has created a greater attention around OSR. Jørgensen does not think that the regulations in Norway will be changed as the oil industry move north, but he is of the opinion that Klif is setting tougher OSR requirements. He emphasizes that it is up to the oil companies to prove that they are capable of dealing with the challenges they meet. As they have to document an ability to increase their oil spill preparedness, this may also drive innovation, says Jørgensen.

5.1.3 Miros

Interviewee: **Erik Sandsdalen (Managing Director of Miros, and board member in NOSCA**
Date of interview: **17th February 2012, 13th March 2012**
Location: **Phone interview, and conversation at Interspill 2012**

In Norway there are only two big buyers, NCA and NOFO, and according to Sandsdalen all companies do everything they can to be on good terms with these two. However, he stresses that no company in Nosca can survive by only selling to these two actors, because they are far from big enough to cover the demand needed by the suppliers and because their purchasing system is based on large purchases every 5-10 years. Therefore, Norwegian OSR companies must also sell internationally. He emphasizes that both NCA and NOFO are aware of this, and encourages this as suppliers then become economically better off, with resources to produce and innovate new products. Sandsdalen states that the only way into the Norwegian market is through NCA or NOFO, and that by getting on the inside one gets a head start and a good reference for business abroad.

According to Sandsdalen the Norwegian government is satisfied with NOFO. Also NOFO's members have figured out that if the government shall continue to be satisfied, they have to encourage the supply industry to innovate further. One way to do this is to give out small grants for development, in addition to the development they already do. Sandsdalen is impressed by NOFO's development initiatives.

Sandsdalen stresses that the claim from certain environmental protection organizations, that there has not been product development or innovation in the OSR industry, is a truth with qualifications. He emphasizes that there has been development and innovation for skimmers and lenses, but highlights that the major development have happened on electronic utilities like radars and sensors and believes that there will happen a lot in this sector also in the years coming. Sandsdalen stresses that on a general basis, all companies must innovate to survive, also in the OSR industry.

According to Sandsdalen, Norway has a good reputation worldwide when it comes to OSR. Norwegian suppliers are listened to by international companies, and if they have a link with NOFO or Statoil it is considered very positive. He also points to the fact that Norway is one of the few countries that allow oil on water exercises for training and testing of equipment. These exercises and the interaction between the government and the supply industry give Norwegian operators and suppliers a unique advantage. It is also beneficial for the supply industry because the equipment used in these annual exercises is faster worn out and needs to be replaced more frequently.

Sandsdalen is worried by the fact that a major accident or oil spill is needed in order for the government to react and initiate innovation and development programs. He points to the Norwegian government, which just 4-5 years ago were very passive and did not invest in OSR. Following the Full City accident in 2009, which caused damage on densely populated coastline, NCA was granted more than 300 MNOK. «We never manage to be precautionary», says Sandsdalen. He adds, however, that the OSR has become relatively good in recent years and predicts that government investments will level out. On the other hand he points to Brazil, Mexico, Australia and Western Africa as emerging and growing markets.

5.1.4 Norwegian Petro Services (NPS)

Interviewee: **Stein Thorbjørnsen (CEO)**
Date of interview: **13th February 2012**
Location: **Phone interview**

This interview was conducted one and a half month before NPS was aquired by DNV. At the time of the interview, the authors of this thesis did not have any knowledge about this aquisition.

NPS is a consulting company started in 2006 that delivers plan and advisory services for OSR. In addition NPS supports companies that work with technology development. Thorbjørnsen informs that NPS works both on the general planning level and on the operative level. He points out that NPS is almost alone in Norway in delivering consulting services for coastal OSR, and Thorbjørnsen thinks that the future looks bright for NPS with a steady growth of 15-20% per year. They were merged with Arctic Protection for a period of time, but got negative reactions from certain companies because of the tight link between consulting and operations. This led to a demerger in 2010.

In contrast to production and operation companies that are very dependent on NOFO and NCA, NPS has a wider market with a higher proportion of private companies. Thorbjørnsen informs that less than 1% of NPS' total income comes from NCA, and the rest are oil companies, NOFO and other private companies. ENI has been their biggest customer, and they sell much more consulting services directly to the oil companies than to NOFO. He also states that the IUA have potential to be good customers for NPS because of the generally low knowledge level of OSR, but that they are marginal customers because of their lack of funding.

Thorbjørnsen considers the market to be dysfunctional. It is not a natural and well-functioning market, as it is controlled by only two big actors. He stresses that a significant element in the market is that there out of principle is no one that wants to do anything without getting a governmental order to do so. This means that requirements and guidelines given by the government control the OSR market. He compares it to insurance and clean water and states that «everybody wants it, but no one wants to pay for it». The risk of a possible oil spill is also considered to be very low, and the investing in OSR is often perceived as a unnecessary use of money. Thorbjørnsen has also observed some complaining among NOFO members, as operators far off shore do not want to pay for the increasing costs of OSR systems near the coast. It is not welcomed by the oil companies that the cost of OSR becomes a larger budget post.

He does however believe that the requirements given sometimes are not tough enough, and points to Goliat where ENI has established a stronger OSR because the required response system was considered inadequate. He emphasizes the huge difference between OSR close to the coast and far off shore, and believes that some platforms far off shore might not need an OSR system at all, at least when taking the environmental risk and related operator requirements into consideration.

Thorbjørnsen believes that the market for OSR products, including consulting, will grow, and the fact that the oil industry moves north will contribute to this growth. He stresses that it must be a bigger pressure on oil companies to have an operative and functional OSR and not just what he calls «paper response». A partial privatization of the OSR market is considered necessary for further development, says Thorbjørnsen. Only heavy pressure from the government or the occurence of a major accident will make this happen.

5.1.1 Arctic Protection

Interviewee: **Harald Karlstrøm (CEO)**
Date of interview: **20th March 2012**
Location: **NTNU**

From 2008 to 2010 several different OSR companies near the Barents Sea merged and took the name Arctic Protection. Karlstrøm explains that the plan was to create a company that could supply both OSR planning and operational services, which in turn could be sold as a package. They did, however, get strong, negative reactions to this, both from ENI and NOFO. This meant that the company split up again, and Arctic Protection went back to concentrating solely on operations. Karlstrøm believes that the reason for this was that NOFO wanted a flat supplier structure and are generally skeptical to integrated services.

Autumn 2010, Arctic Protection approached NOFO with a new concept for a «fishing boat response». They offered to organize local fishing boats, with which Arctic Protection had a network and a good understanding of, to create an OSR unit, and deliver the whole package to NOFO. Karlstrøm believed that this could be an ideal way for NOFO to organize their activities in Northern Norway and also create spillover effects for the region. NOFO's response was strongly negative. Karlstrøm believes the reason for this was that NOFO wanted total control over the implementation process of the new coastal concepts specially developed for the Goliat oil field, and was at that point not happy to delegate major parts of it to subcontractors like Arctic Protection. In 2011 Arctic Protection met with NOFO again, this time asking NOFO to tell them what they wanted Arctic Protection to do. This meeting resulted after some months in NOFO delegating to them the setup of the IGSA coastal task force, one of the new Goliat coastal consepts.

Karlstrøm stresses that Norwegian export of OSR equipment is good, but the natural next step is export of services and concepts. The problem is that almost every OSR service and concept in Norway is operated by NOFO and NCA, which are organizations that do. not export.

Karlstrøm emphasizes that many oil companies (with a few good exceptions) push most of the OSR responsibility on NOFO, while it is actually the oil companies that are responsible for their own OSR plans, documentation and operations. He also believes that the requirements set by the government until now have not been good enough, and that NOFO now meets the new challenge to operate closer to the coast with shorter response margins and higher operationality.

He highlights that ENI's OSR for the Goliat oil field outside Hammerfest is good and exceeds government requirements. This is, however, not necessarily making ENI any more friends in NOFO. More money and effort into new OSR concepts creates precedence, according to Karlstrøm. He expects tension among the 30 members of NOFO, especially as companies operating far off shore are not interested in paying for extra investments in specific coastal operations. This calls for new cost sharing principles and agreements within NOFO. Karlstrøm is skeptical to the two statements that (1) NOFO is an important cost-sharing organization and that (2) OSR is too important to be privatized. He believes that coastal OSR probably can be done both more efficient and cheaper with more extensive participation by private local actors.

Because several governmental departments are involved in OSR, there are also conflicts of interest and lack of communication and coordination in the oil spill politics. Karlstrøm points out that it is only the Ministry of Trade and Industry that considers OSR as a value-adding industry, while other governmental departments consider OSR to be a solution to a problem induced by Norway's most profitable industry. This results in a lack of consensus and awareness and also reluctance against radical change in the framework and politics for the oil spill control business.

Karlstrøm is worried about the innovation drivers in the OSR market. He believes that there are few requirements for better technological solutions, and therefore there are few if any incentives to develop new solutions, which is both time consuming, expensive and risky. Karlstrøm calls for a situation where technology is a competitive advantage, which in turn would be an innovation driver. Karlstrøm argues that while the oil industry technologically has changed radically with a number of radical innovations the last two decades, the OSR industry is very similar to what it was twenty years ago. There have been developed some new and improved boom systems and some other equipment but as a whole it is much the same. He believes that a restructuring and partial privatization of the market could stimulate the innovation intensity in the business. Rewarding oil companies that have shown something extraordinary in developing solutions to the challenging coastal OSR area with an advantage when applying for new attractive near coast oil prospect licenses, can be another. This will, according to Karlstrøm, give a new dynamism in the OSR industry based on economic and industrial incentives.

5.2 Oil companies

5.2.1 ENI Norge

Interviewee: **Ole Hansen (OSR advisor)**
Date of interview: **30th April 2012**
Location: **Phone interview**

ENI has an area of interest in the High North in general, and Goliat specifically. Hansen emphasizes that ENI focuses on coastal contingency and sensing/detecting solutions in order to improve their OSR. He lists several challenges connected to OSR in the north. (1) First is the fact that many fields, including Goliat, are much closer to the shore than oil fields further south. This implies a need for shorter response times and a more operational and standing OSR. (2) A second challenge is the sparsely populated areas in Northern Norway with less infrastructure, which results in longer reponse times and less accessibility. (3) A third challenge is the long periods of darkness north of the Polar Circle.

In order to cope with the need for shorter response times, Hansen highlights the newly developed fishing boat response (in cooperation with NOFO), and the IGSA as two specific measures. He confirms that the fishing boat response will be operative before ENI starts production drilling in October 2012, and that there will be conducted a verification exercise in September 2012 including both the fishing boats and IGSA.

Hansen stresses that there is a lot of innovation happening outside NOFO. He informs that ENI Norge and Statoil have run more than 30 OSR development projects during the last five years, and that several of these projects have been continued by NOFO, which commercialize them. On the other hand only a few of all development projects are considered a sufficient improvement of the OSR. The majority of the projects are considered to have too low cost-benefit efficiency and it is therefore chosen not to implement them. It is, according to Hansen, a common perception in the market that it is not worth investing in incremental innovation for open ocean OSR because the benefits are too low, and that this is one of the reasons why there has not been new breakthroughs in this area. He also stresses that the OSR of the future should focus on coastal contingency and beach clean-up processes, and believes that Klif will impose stricter requirements when the oil industry move closer to the coast.

Another important aspect that Hansen emphasizes is the fact that each oil operator decides their own acceptance criteria for environmental risk. He informs that ENI's activity is far within these limits even with no OSR at all, but stresses that OSR is a priority area for ENI and they use it in marketing and PR. Hansen also stresses that the level of OSR competence varies a lot between companies. He thinks that companies with higher competence on OSR also are more focused on it. He believes that the key to increased focus on OSR is increased OSR competence and knowledge in the oil companies. There are, according to Hansen, two ways to do this: One is that the oil companies themselves increase investments and the focus on OSR, another is that the government imposes stricter requirements.

5.2.2 Statoil

Interviewee: **Frode Engen (OSR advisor)**
Date of interview: **4th May 2012**
Location: **Phone interview**

Engen states that Statoil wishes to be a driving force in OSR development. Statoil is aware that it is a big actor on the Norwegian continental shelf, and that there are many other companies looking to what Statoil is doing. He informs that Statoil has the biggest share in NOFO, and that several important persons in NOFO come from Statoil, including the current CEO, Sjur Knutsen.

Engen informs that the OSR on Goliat will become the most advanced OSR system on the shelf, and that it will be the OSR forefront in Norway. Because Goliat is located in a new area, Statoil has had the opportunity to start from scratch and has not needed to base the OSR on established systems. New areas of focus on Goliat are coast and beach OSR, and they want to develop more thought-through solutions at Goliat. He expects that new requirements from Klif will be in line with what Statoil are developing at Goliat.

Engen emphasizes that there already are contingency systems in Finnmark, in the form of Coast Guard vessels and NCA systems, but that they have not been systemized as they have in Southern Norway. He informs that Statoil initiated the development of the fishing boat response. The process with NMA to change the rules for use of fishing boats was long, but Statoil are satisfied that the rules now are changed.

Statoil has its own R&D department for the development of new technology. Engen emphasizes that they have systems in order to cope with new governmental requirements as fast as possible. Statoil runs its own technology projects and also collaborative projects with NOFO. Most development processes can be done fast and efficient, but if the development requires change in governmental rules and conditions it is much longer process, informs Engen. He emphasizes that most development projects run by Statoil are based on an identified gap or proposals from the supply industry, and not continuously running R&D projects.

Statoil are active consumers of consulting services and use companies like DNV, NPS, Akvaplan Niva and Acona to develop environment risk analyses and emergency preparedness analyses. Equipment purchases are channeled through NOFO. Regarding international business, Engen informs that Statoil does not favor Norwegian supply companies over others, but that the most technologically advanced company will be chosen if the offer is good enough.

Engen believes that Statoil has a good OSR, but stresses the importance of continuous development. Currently they are focusing on OSR close to the oil spill source in addition to new systems for application of dispersants. Both these challenges have been handed to the supply industry. Statoil has also addressed new boom and pump technology for a longer period of time, but nothing revolutionary has appeared so far. There is however a number of projects currently going on that Engen hopes will improve the technology.

When looking at drivers for innovation, Engen emphasizes oil spill incidents and governmental requirements as the most important. He highlights that the regulations are based on the BAT-requirement (Best Available Technology). He also believes that the opinion of the people can be important but that the public OSR knowledge is too low for this to be an important innovation driver.

Engen stresses that it is important for Statoil to technologically always be in front. He highlights Aptomar as an example of Statoils development projects, and informs that Statoil has collaborated with Aptomar for several years, first to get the company up and running and now because they deliver the best systems.

There is no link between the amount of money spent on OSR investments and the possible cost of an oil spill, informs Engen. If Statoil were to calculate it, the OSR would be zero because of the microscopic probability for a major oil spill. Engen informs that he has never seen an evaluation that links OSR investment and possible cost of an oil spill. He stresses that taking the consequences of your actions and cleaning up your spill, regardless of high or low environmental risk, is an important principle for Statoil. He also states that Statoil generally is far inside the acceptance criteria for environmental risk even with no OSR at all.

Engen stresses the importance to hold on to today's system for OSR, where NOFO and NCA play important roles, and believes that it is not beneficial to continuously reorganize. He does however emphasize the importance for continuous development.

Engen believes that it is the oil industry that should be responsible for OSR development and innovation for oil activity. For ship-wreckings and other accidents not related to the oil industry he believes that NCA and the government are responsible. He emphasizes that there are many technological differences between OSR far off shore and OSR in coastal waters, but that it is important to collaborate where it seems appropriate. The fact that the oil industry is moving closer to the coast may also trigger a tighter collaboration between NCA, NOFO and oil companies.

5.3 Organizations, government & other actors

5.3.1 NOFO

Interviewee: **Trond Mauritzen (CFO)**
Date of interview: **17th February 2012**
Location: **Phone interview**

The purpose of NOFO is to support the OSR of the oil industry on the Norwegian continental shelf. NOFO does not make any contingency plans, this is done by the oil companies. Plans are sent to Klif for approval and approvals may be given with or without remarks. NOFO has a pure operative role, and build OSR systems based on contingency plans developed by the oil companies and requirements by the government. Mauritzen stresses it is the oil company that operates the field that is 100 percent responsible for an oil spill, and that NOFO is only there to support and has no economic liabilities beyond this. All this is based on the Pollution Control Act. NOFO does not work politically, as it is The Norwegian Oil Industry Association (OLF) that does this. He also stresses that NOFO has no commercial activities. They buy and/or rent equipment and services, but do not sell anything.

Mauritzen informs that NOFO is designed to capture the oil as close as possible to the spill site, which means far off shore and close to installations. If oil escapes the barriers and comes close to or hits the coast, NOFO has access to other resources and personnel in addition to their own equipment. He informs that NOFO can and has supported NCA in operations on water.

Mauritzen describes NOFO as a centrally controlled organization, but that they attempt to involve local resources in their OSR activities. The way that NOFO does this is by employing people on-call, so OSR comes in addition to their regular job. He emphasizes that there are a lot of people who are willing to participate in OSR activities in order to protect their local environment.

Ice-covered water is not a topic in NOFO yet. Ice is only an issue in the North Barents Sea where there are no oil exploitation today and will not be in the nearest future.

5.3.2 Norwegian Coastal Administration (NCA)

Interviewee: **Steinar Lodve Gyltnes (Head of Department of Logistics and Technology)**

Date of interviewa: **28th March 2012. 24th May 2012**

Location: **Phone interview**

Gyltnes explains the division of responsibilities between PSA, NCA and Klif. In his opinion it works well, and he does not believe that a merger between these three departments would be beneficial.

NCA recommended in their 2000/2001 Emergency Preparedness Analysis (EPA) that the government should consider establishing a national dispersion response. This has not yet been done. The new EPA from 2011 points out that dispersion gives a net environmental benefit when used in some of the scenarios described in the analysis.

The Norwegian government ran its own R&D programs until the middle of the 1990's. Since then they have not done any R&D themselves but subsidized external programs through Innovation Norway and The Research Council of Norway. NCA also cooperates closely with NOFO, and assists with knowledge, competence and facilitation. They have quarterly meetings and participate in each other's exercises. Gyltnes says that close cooperation with NOFO is necessary because of NCA's role as coordinator of the national OSR. He also emphasizes that it is a beneficial cooperation that will benefit both in the event of an accident. In addition, it is much easier for NCA to deal with one actor instead of 30 different oil companies, and Gyltnes is convinced that the coordination through NOFO is appropriate.

When it comes to purchasing, Gyltnes emphasizes that all purchases of more 500 000 NOK are put on tender. There is no cooperation between NCA and NOFO on purchasing. However, as NCA is responsible for the national OSR system, Gyltnes says that they do take into account what NOFO buys when they evaluate what to invest in. There is no need for double capacity, he says, so they may cancel some purchases and even scale down on some equipment. It is an overall evaluation, says Gyltnes, and comments that this also includes equipment in Sweden, Denmark, and Russia.

Gyltnes emphasizes the importance of NCA being aware of its numerous roles. Being both an oversight agency and an emergency response organization, and also a buyer of equipment and services, is both a challenging and a convenient solution, according to Gyltnes. He believes that being close to the accident through their operations makes NCA a better oversight agency and that NCA because of this is perceived as professional and competent.

He also stresses that NCA, NOFO, Innovation Norway and The Research Council of Norway all have an interest in stimulating the supply industry. He thinks that it is a success factor to include the industry, and that this cooperation gives good projects that can be used in the operative OSR. When asked if there are too many governmental departments that have an interest in OSR and OSR industry, he is of the opinion that all the different interests are coordinated by The Research Council of Norway. He highlights that The Research Council's role is to advertise programs in relation to the government's priority areas. He also emphasizes that it is quite clear that it is the Ministry of Fisheries and Coastal Affairs and none other that is responsible for acute pollution.

When questioned about the suppliers' caution of criticizing the system, Gyltnes agrees that this is problematic. However, he questions whether the suppliers' feelings on this issue are anchored in reality. He agrees that the OSR market is no easy market to operate in—with two major buyers it is hard to get one's products through—

but he points to that there are also other private companies that request OSR products. Also, although he says that some of the criticism probably is justified, he maintains that NCA always is interested in new ideas, and invite companies to present them.

Facts about NCA are summarized on page X in chapter 2.

5.3.3 Sintef

Interviewees: **Stein Erik Sørstrøm,** Research Manager at Sintef and Program Manager for the joint industry project «Oil in ice» and **Ivar Singsaas,** Research Manager at Sintef.
Date of interview: **22nd March 2012**
Location: **Sintef Brattøra, Trondheim**

Sørstrøm explains that there are three main actors with three different roles in OSR in Norway: (1) Klif sets requirements, (2) NOFO and NCA are the main OSR operators, and (3) the oil companies, the shipping companies and others that use or transport oil are the main polluters.

He explains that there are mainly three different methods that can be used to get rid of an oil spill: mechanical recovery, dispersion and in-situ burning. Mechanical recovery is by far the most common countermeasure in Norway, but dispersion is becoming more important. The issue with dispersion is primarily linked to cost, that it is expensive to buy and store dispersants. In-situ burning is almost never used, but is a very effective method under the right conditions. Sørstrøm and Singsaas point out that dispersion and burning are more common in other countries, and that UK's OSR is mainly based on dispersion.

Excluding cost, the most difficult and complex task is to choose and use the right OSR method at the right time, says Sørstrøm. One can for example not use dispersion in shallow waters because it can damage the marine resources below the surface.

Sørstrøm stresses that the Norwegian OSR market is a peculiar market with only two big customers, NOFO and NCA that dominate the development. He emphasizes that the innovation drivers that exist in other markets do not exist in the OSR market. He mentions several different reasons for this.

One is the lack of certification, which in turn leads to no formal requirements for OSR equipment.

Another reason can, according to Sørstrøm, be that there are only two big buyers in the market. The drive to always be better than the competitors is less pronounced in the OSR industry compared to other markets, and this worries Sørstrøm. Also, investors may be reluctant to enter the OSR market because there are too few buyers.

Third and most important, he emphasizes the missing link between the cost of an oil spill, and the money invested by an oil company in OSR equipment and services. The main reason for this, according to Sørstrøm is that there has never been a major offshore accident in Norway that has caused damage to the coast, and installations such as aquaculture installations and tourist sites along the coast. Because of this, no oil company on the Norwegian continental shelf has felt the cost of a major oil spill. He exemplifies this pointing to a minor oil spill connected to an O&G operation in Brazil, where Brazilian authorities ordered total shutdown of the specific O&G company's activities in Brazil for a period of time. Sørstrøm thinks similar reactions in Norway would drive the innovation for new and better equipment. Another reason is the belief that an oil spill will be costly no matter what equipment that is used, and therefore it is hard to see the link between cost and benefit. He adds that much of the same problems is seen in the shipping industry where ships are covered by a shipping insurance pool, and the ship-owner or ship-operator do not pay directly for an oil spill themselves, alienating the actual consequences of an inadequate OSR. If the link between oil spill investment and oil spill cost becomes clearer to the operator (buyer) this will also drive innovation, says Sørstrøm.

Regarding innovation today, Sørstrøm highlights that most of it is incremental, improvements of existing solutions. He believes that the reason for this is that the technology development is driven by the supply industry. Most new products will necessarily be new versions of old products. He calls for stricter laws and requirements, and that when a new and better solution is developed, it should also be required to be certified.

He understands that NCA has small budgets, but argues that it should be a priority to allow more time and money to R&D on OSR. Sørstrøm also stresses that Sintef have several new solutions for OSR concepts, but that it is difficult to get financing for commercialization..

Sørstrøm informs that much more money is used by oil companies developing precautionary equipment and products, in order to prevent an oil spill happening in the first place. This is barrier «0». But time and time again one sees that it is not good enough, says Sørstrøm.

5.4 Other inputs from interviewees and informants

More than 30 interviewees have provided both objective facts and personal opinions for this thesis. The information that follows is a summary of the inputs from the interviewees. Because some wanted to be anonymous, this chapter will treat all this information as anonymous. The anonymity issue will be discussed in chapter 6.

Several interviewees criticize the way NOFO and NCA work. None of the interviewees want to do this publicly, all for the same reason. They are utterly dependent on a good relationship with both big buyers in order to stay in business, and are not willing to risk this relationship by expressing their opinions publicly.

Criticism against NOFO is most prominent. One is that NOFO is perceived as old-fashioned in both their thinking and in solutions. An example is that the organization was quite reluctant to participate in coastal preparedness, rather wanting to concentrate on what they had always done, OSR far off shore. Only after political pressure from oil companies, the government, and interest organizations did they start to develop an OSR for coastal waters.

Some interviewees also perceive NOFO as arrogant. The reason stated for this is NOFO's reluctance to listen to local and regional knowledge. An example here is that some IUAs in the past chose not to have collaborative agreements with NOFO, because they felt they were not heard, and that the benefits were few relative to the costs.

NCA is criticized for their multiple roles. Several interviewees are critical to the fact that NCA acts as buyer, operator and supervisor. Even though NCA believes that this is a beneficial organization, interviewees suggest otherwise. One example that is highlighted is the close cooperation between NOFO and NCA, when in fact NCA is supposed to supervise NOFO. NCA is also criticized for favoring certain suppliers. It is a perception among several interviewees that NCA maintains certain suppliers even though all contracts are put on tender.

It is a general perception that oil companies that increase their OSR investment raise the bar for other oil companies. This is not always welcomed, as it implies generally higher OSR costs. Since oil companies develop their own requirements for OSR, the norm and perceived standard in the market has a lot of influence. When someone raises the bar for OSR, the rest will also have to increase their OSR investments in order not to be perceived as irresponsible.

A belief among several interviewees is that the buyers are satisfied with the solutions that exist today, and that this has a negative influence on innovation. It is also expressed negative opinions on the fact that Klif bases their requirements on existing solutions, the best available technology (BAT), and that this in turn has a negative influence on innovation.

A last input to be mentioned here is that the annual Oil on Water exercise is evaluated as very limited. Even though it is conducted in open sea, the amount of oil used is not enough to simulate an actual spill. This contradicts inputs from several other interviewees stating that Oil on Water is a unique exercise and a reason why Norway is one of the leading countries in OSR.

6 Discussion

This chapter will discuss the Norwegian OSR as a technological innovation system (TIS) using the seven key functions described in chapter 3. First, the state of the technological innovation system is assessed through a structural and functional analysis of the TIS functions. This analysis will answer expectations 1 and 2 directly (see Box). The analysis will then bring to light issues that are relevant to expectations 3-7. Out of the analysis one will be able to synthetize the main mechanisms in the market.

6.1 Are the TIS functions fulfilled?

This chapter will assess each of the seven TIS functions. The analysis is done in two steps: first *structural fulfillment*, then the *functional performance*. This will reveal how the different functions contribute to the TIS, and whether it is a result of a lack of structural elements or that the elements themselves do not function properly.

Bergek *et al.* (2008) suggests two ways of approaching the assessment of how well the TIS is functioning: (1) relating the system functions to the

REVISITED // Expectations stated in chapter 3

1. Functions that affect the TIS positively are *influence on the direction of search, legitimation,* and *resource mobilization.*
2. Functions that affect the TIS negatively are *knowledge development and diffusion, entrepreneurial experimentation, market formation,* and *development of positive externalities.*
3. Macro features of OSR contribute to innovation positively.
4. Government regulation and support schemes contribute to OSR innovation positively.
5. The concentrated buyer power limits the sellers' contribution to innovation.
6. The funding of the buyers limits the buyers' contribution to innovation.
7. Opportunities in the OSR industry are still to be found in equipment production.

phase of development of the TIS, or (2) comparing with another TIS. The approach chosen here is option 1.

As will be argued in chapter 6.1.4, the market for equipment producers seems to be a mature market, while the market for service producers seems to be in a nursing phase. From here on, the functions will be evaluated mainly as in a mature market, but considerations specific to the services market will be included when necessary.

6.1.1 Knowledge development and diffusion (Function 1 of 7)

Part 1 - Structural evaluation:

This function treats issues of the knowledge base and its development, such as the variety in the knowledge base and the orientation of R&D projects.

The knowledge base of OSR technology is broad. In the early stages of OSR development in Norway, knowledge development was purely technological. It was based on experimentation in the firms, such as in the government-owned Main Station for OSR Ltd. In later stages of development, also knowledge on response organization and logistics developed. Application-specific knowledge was developed through the adaptation of equipment to fit Coast Guard vessels, vastly expanding the reach of the OSR in the early 1990's. In addition, knowledge on foreign markets increased with the establishment of NOSCA in 1993, which aims to promote Norwegian companies abroad.

There is a high degree of technological variety in the knowledge base. It involves all the scientific technologies described in chapter 2.2. All of them are, or—in the case of in-situ burning—will probably become, necessary for an integrated response.

The knowledge base of OSR includes the whole value chain. Core competencies are located in the *OSR industry firms*, in some of the *major buyers*, and in *research institutes*.

The *OSR industry firms* have deep knowledge of their specific field, obtained through development, often over many years. Both *major buyers* NCA and NOFO have accumulated knowledge from a number of oil spill exercises and operations over the last decades. Also, *research institutes* such as Sintef do basic research that builds the foundation for new technologies, and applied research in collaboration with the industry in Joint Industry Projects (JIP). An example of this is the Sintef JIP «Oil in ice», a project that involved six oil companies and 10 other partners.

Also *oil companies* contribute to the development and diffusion of knowledge. OG21, the oil industry strategy group, has developed Technology Target Areas, one of which is environmental technologies. OSR is included here. This is typical of the oil industry approach, that the practical issues of OSR are included as one of many elements in an environmental package. An example of oil industry involvement is ENI and Statoil's collaboration on OSR development in the Goliat oil field project. These companies have also initiated the development of technology that has been continued in the NOFO program «Oljevern 2010». However, it has been mentioned in several, ENI among others, interviews that the OSR-related knowledge in the oil industry is fairly low, at least in smaller companies.

Other structural elements that contribute to fulfill this function are Petromaks, the RCN program for petroleum research, and Innovation Norway.

The function *knowledge development and diffusion* is evaluated to be **fulfilled structurally**. How well does the function perform?

PART 2 - FUNCTIONAL PERFORMANCE:

According to Sintef, Innovation Norway and several other industry actors, innovation in this industry can be described as almost solely incremental. An example is that oil booms have been improved in certain areas, e.g., to self-expand and to handle stronger currents, but mechanical recovery of oil is done almost the same way today as 20 years ago. Why is this? It may seem that the structural elements of this function promote such incremental innovation.

Since 1993, the OSR and the oil industries have run innovation, in or outside of collaborative arrangements, as NCA no longer is a direct organizer of innovation activities. The government does however provide opportunities for support through Innovation Norway or RCN. Establishing strong support schemes is a major role of government in innovation (KEMP 2000, PORTER 2000).

Interviewees have expressed the government withdrawal from running innovation as a peculiar situation, as NCA is the agency with the overall responsibility for coastal safety, and that their withdrawal may have lead to little development tailored to the specific needs of NCA and its coastal responsibilities. Also, the following issues are brought up for future developments:

- If run by the OSR industry or research institutes, innovations have become reliant upon government funding, due to lack of own funds.
- If run by the oil industry, innovations have had to overcome strict,

short-term cost-benefit assessments. ENI and Statoil confirm that these restrictions have ruled out certain new developments.

In recent knowledge development, one of the often-mentioned contributors is the technology development program «Oljevern 2010». The project has a total funding of 90 MNOK to develop and commercialize new technology, which results in an average funding per project of 4.5 MNOK, apportioned over 3 years. This is one of few positive contributions to this function. However, the constraints in funding and time rule out more basic research and many suggest incremental improvements. It should also be included here that the yearly exercises, both Oil on Water and others, provide basis for further continuous improvement.

The function is **not working well**. The establishment of longer-term funding for specific developments could arrange for increasingly radical innovation.

6.1.2 Influence on the direction of search (Function 2 of 7)

Part 1 - Structural evaluation:

This function treats issues that guide the search for new solutions, such as current events, regulatory pressures, lead customer demand, technical bottlenecks, and the belief in growth.

An important influence on the direction of search—as mentioned by several interviewees—are large-scale oil spills that occur with irregular intervals. An example is that the 2007 Server accident on the Norwegian coast resulted in the development of the Coastsaver Quick Response oil boom. A general opinion among interviewees is that the occurrence of accidents is an important impetus for development in the oil spill industry.

Another influence on the direction of search is regulation. When planning new developments, private companies assess the environmental risk and dimension the emergency response according to this risk and current governmental regulations. This planning is then reviewed by Klif, the Climate and Pollution Agency, which approves or assigns additional requirements. Klif's requirements are based on a principle of Best Available Technology (BAT), which is the presumed leading technology in the market.

Demand from leading customers impacts search. An example of such demand is the NCA Emergency Preparedness Analysis. The analysis from 2000 has now been fully implemented, except a national dispersion response, which is currently in development. The most recent analysis from 2010 influences the direction of search by specifying the current needs of NCA.

Technical bottlenecks will also have an impact on search. Examples of such bottlenecks are the short windows of opportunity for use of dispersants and in-situ burning, and weather conditions such as currents and waves. Sintef and other research organizations are actors that contribute to the solution of these issues, as do universities. Results from research projects in these institutions will guide the search in new directions.

Lastly, an influence on the direction of the search is the prospect or potential of future growth. A belief in the growth potential of the industry will affect the search for new solutions, in the way expectations of growth into Arctic areas have fueled research on OSR equipment in Arctic conditions. Recently, DNV acquired NPS as part of their strategy for the Arctic areas.

The function *influence on the direction of search* is evaluated to be **fulfilled structurally**. How well does the function perform?

PART 2 - FUNCTIONAL PERFORMANCE:

Recent oil spills have motivated the development of certain new solutions. However, this only in the short term, as the attention both from the media, the politicians, and the public seems to drop rapidly after a spill. This short attention span is discussed in more detail in chapter 6.1.5. Interviewess have commented, in a joking manner, that spills should happen more often retain attention on OSR.

Regulations have a clear positive influence on the direction of search. The regulatory agency Klif has signaled tougher requirements towards the oil industry. Such an official statement, or the anticipation of it, may intensify the search. The most recent example is the set up of the IGSA task force, where anticipation of regulation spurred demand from leading customers. This is a clear example of how future development might be influenced by governmental involvement on the regulatory side promoted by, e.g., Porter (2000). However, the BAT requirements are described by interviewees as «woolly». As there is no formal certification scheme in place for OSR products, such requirements may not have the wanted effect. This is a drawback for the effect of regulation, and is a challenge for regulatory strigency. As discussed by Kemp (2000), stringency in regulation is necessary to promote a radical technology response.

The customer demand does also has a positive influence on this function. Such demand has lead to demonstrable improvement. Also, the NCA Emergency Preparedness Analysis (EPA) identifies gaps that NCA aims to fill, and thus articulates some of their demand. However, the EPA does not directly discuss further innovation and development, only how the gaps can be filled by the existing solutions.

Research institutions play an important role in the solution of technical bottlenecks. Sintef has developed new solutions for OSR concepts, but has recently lacked funding to commercialize them. Even so, such development provides momentum and direction for further research.

A belief in growth has the potential to spur development in this field. Interviewees express positive views for the near future, as 2011 has been a record year for several companies, and 2012 is expected to be even better.

The function is **working well**. An improvement would be a stronger guidance of search by NCA.

6.1.3 Entrepreneurial experimentation (Function 3 of 7)

Part 1 - Structural evaluation:

This function relates to issues of experimentation with new solutions, such as the number of new entrants, and the occurrence of diversifying established firms.

In chapter 2, 16 of the most important companies in the industry were researched. Out of these well-established firms, only four companies were established after year 2000. However, of 16 new Norwegian projects (excluding the international actors) in the NOFO program «Oljevern 2010», ten were established after year 2000. This indicates that there is some experimentation in the Norwegian market.

There are several examples of diversifying established firms entering the OSR market. OSR makes up only 7-8 percent of Frank Mohn's total business, but due to the size of the company, Frank Mohn still accounts for almost a third of the total Norwegian OSR market. Aadi, DNV, Henriksen and Seaworks are other examples of companies that have diversified into this market.

The breadth of technologies in OSR is large and to some extent complementary, as described in chapter 2. Experimentation within and between these technological areas may generate new solutions in the OSR market.

Even though there is a broad set of technologies involved, the range of applications of OSR equipment is generally limited to the OSR market. This is a drawback for experimentation. However, this does not hold for the radar and remote sensing technologies.

There is a wider range of applications, as the technology is used by many types of marine vessels for different purposes, and therefore a bigger market. This difference is reflected in the numbers of new entrants into the OSR market. As mentioned above, ten out of 16 Norwegian projects in «Oljevern 2010» originated in companies established after year 2000, and six of these were on remote sensing and radars. Only two were projects on mechanical recovery. This indicates that there is little experimentation in traditional OSR, but more experimentation within the area of remote sensing and radars.

The function *entrepreneurial experimentation* is evaluated to be **structurally only partially fulfilled**. How well does the function perform?

PART 2 - FUNCTIONAL PERFORMANCE:

Bergek *et al.* (2008:416) argue that «a TIS without vibrant experimentation will stagnate». In OSR, this may be the case, even though «Oljevern 2010» contributes positively. The number of new entrants into the industry is low. Only four of 16 companies in table 2 were established after the year 2000, and their income is low relative to older companies. The degree of patenting also reflects experimentation. A patent search by Oslo Patent Office turned out only 20 patents granted, since 1987 (chapter 2.5). However, this list does not seem to include patenting in remote sensing technologies.

It should be kept in mind that the OSR market is evaluated to be a mature market. Lower entrepreneurial experimentation than in nursing or bridging stages is natural (BERGEK *et al.* 2008). Still, there are also few entrants into the market for operational services, which is seen as a nursing market. This may indicate an overall lack of drivers inducing entry.

The function is **working**—for a mature market—but there is a lack of drivers inducing new firms to enter the industry.

Part 1 - Structural evaluation:

This function treats the creation and development of markets, the buyers and their purchasing processes, the demand profile, and market uncertainties.

The formation of the Norwegian market for OSR started in 1954, and developed gradually until the establishment of the Oil Spill Council in 1971. In the following years there was a major expansion of the Norwegian OSR as described in chapter 2.1.3. Thus, there has been a market for such products, with both governmental and non-governmental buyers, the last 40 years.

Until now, the OSR market phase has been assumed mature. The arguments for this assumption are that there is stability in both structural and technological terms, a stable regulatory system, and a handful of actors dominating (Bergek *et al.* 2008). But there is also a very unclear demand profile, and there is high uncertainty regarding the OSR services market. Still most factors point toward a mature market—for equipment. For service providers, the market seems to be in a nursing phase.

The main buyers in the market are NCA and NOFO, and only to some extent the operating oil companies. This dynamic has been described in chapter 2.2. Purchasing processes of the buyers follow competition principles, which for NOFO means involving a minimum of three suppliers. NCA follows guidelines for governmental purchases, which say that all purchases over 500 000 NOK shall be tender-based.

The demand profiles of the buyers are not clearly articulated, which is typical for OSR products overall due to the nature of the technology. Although NCA does articulate gaps in the Norwegian OSR in their Emergency Preparedness Analysis, this does not include general upgrades of equipment or innovation needs. This means that there are strong market uncertainties for these sellers. Buyers, on the other hand, face few market uncertainties.

Lastly, there does exist some institutional stimuli for new market formation in OSR. Governmental regulation may play a role in the formation of new OSR markets. An example is the possibility of increasing demand for services related to specific coastal or Arctic challenges.

The function *market formation* is evaluated to be **structurally only partially fulfilled**. How well does the function perform?

Part 2 - Functional performance:

The main issues that must be discussed here are: the functioning of the established market, e.g., the market structure; potential features that hinder the functioning of this market, e.g., the bargaining power and the demand profile; and the development of new markets, e.g., a market for services.

How can the market structure be characterized?

First of all, what kind of market is the market for OSR? In chapter 3, four conditions for a perfect market were mentioned (Thompson & Formby 1993):

- A large number of buyers deal with a large number of sellers
- Products are regarded by buyers as essentially identical
- No buyer loyalty or preference exists
- All traders are aware of all offers and deals available

How do these conditions apply to the OSR market?

As figure 22 illustrates, the first condition is not satisfied. There are in principle a large number of buyers—33 IUAs, 30 oil companies, and NCA—but in practice there are only two major ones, NCA and NOFO. As was pointed out in chapter 2.4.2, oil companies lack the incentive and IUAs the opportunity to operate as individual buyers in the market.

On the second condition, products (in the different niches) are often seen as similar, though not identical. Different oil booms have somewhat different applications. Some are self-expanding, others are high-speed booms, while some are better suited for working close to boats and in harbors. Skimmers differ in size and capacity for different oil types. It can thus not be concluded that products are regarded as identical.

The condition of no loyalty or preferences does in fact not seem to be satisfied. It has been commented by interviewees that after the first sale is made, one is on the «inside» of the system. An example of this is H.Henriksen, a company that has been working with NCA since the 1980's and is still developing new products with them. Another example is Norlense, which promotes itself as the preferred oil boom supplier for both NOFO and NCA. Even though the buyers stresses the importance of tender-based purchases and emphasize that they do not have preferred suppliers, there is reason to believe that preferences to some extent play a role in the market.

On the condition of ubiquitous information, there is reason to believe that this condition is met. A majority of the interviewees agreed that the market is clear and fairly transparent (Appendix 9). Contracts are also often based on tender. Therefore, this condition seems to be satisfied.

In summary, the OSR market is far from perfect, as it fails on three of four conditions. Interestingly, two of three failing conditions are related to the issue of buyer power (no. 1 and 3). Buyer power is also identified as the main issue in a complimentary analysis based on the Five Forces framework by Porter (1980) (Appendix 10).

Markets with strong buyer power are either monopsonistic or oligopsonistic markets (OECD 2008). As there are at least two strong buyers, it is deemed reasonable to characterize the market as an oligopsony. In the further discussion, this market structure will be assumed.

Before discussing the demand structure in the market, the sources of the bargaining power in the market will be examined.

Where does the bargaining power come from?

Although concentration of buyer power is strong, the oligopsonistic buyer cannot—as a monopsonistic buyer can—reduce the price paid below competitive levels and profit from it (OECD 2008). There is little opportunity to extract unreasonable rents such as quasi-rents, as the seller may decide to leave the Norwegian market instead of agreeing to such egregious terms.

Still, there is strong bargaining power associated with an oligopsonistic market organization. Sources of such power lie in the outside options of buyers and sellers (OECD 2008). How does this apply to the OSR market?

When it comes to the outside option of buyers, NCA, NOFO, and certain oil companies are major organizations. They are relatively larger than most of their suppliers. There is also some degree of competition among suppliers in most technology areas. Thus, all three sources are in favor of the buyer.

When it comes to the outside option of sellers, they may find it difficult to replace a buyer in the Norwegian market, and may thus be forced out. The major buyers are a source of a certain financial dependency due to the size of contracts. The suppliers are also relatively smaller than most of their buyers. Again, all three sources of power are in favor of the buyer.

In addition to these outside options, there are six factors from the Five Forces analysis (Appendix 10) that may be of value in a discussion of sources of bargaining power:

1. The specific product market's importance in the firm's strategy
2. The buyer's proportion of a firm's sales
3. Access to information
4. Switching costs

5. Quality
6. Possibility of backward integration

The *first* factor is that the home market is deemed strategically important by several interviewees, even though the OSR markets are global. There are several reasons that are mentioned by the interviewees: (1) to test new products and concepts in a market one knows; (2) to exploit better technical testing conditions, as Norway is among few countries that allow Oil on Water exercises; (3) to benefit more easily from certain spillovers or information flows; (4) to obtain early revenues that can finance expansion abroad; and (5) to build networks and references. Thus, the factor is a source of buyer power.

A *second* factor is the buyers' proportion of a firm's sales. If the proportion is large, the buyer has a stronger influence on the seller. In the Norwegian market this varies between companies, but research indicates that about half of total income comes from Norwegian buyers, with a majority of this coming from NCA and NOFO. Thus, it is a source of buyer power.

A *third* factor is access to information. It is reasonable to believe that the NCA holds information on many aspects of this market, as described in the previous sub-chapter. Also, one may assume that NOFO knows well what is happening in the market, due to their size, experience, and close cooperation with the NCA. Thus, it is a source of buyer power.

A *fourth* factor is switching costs. Many response technologies work as integrated systems, and can be operated without other specialized equipment. This is the case for oil booms and skimmers. In general, it does not seem to be high switching costs involved. Thus, it is a source of buyer power.

A *fifth* factor is quality. One may present the objection that the importance of quality is paramount to price, and this holds to some extent. Buyer power thus should decrease. A *sixth* factor is that backward integration is unfeasible for any of the buyers. It is not an available means of coercion, which in turn has a decreasing effect on buyer power.

Summarizing bargaining power, there are some very strong factors indicating high bargaining power of buyers. There are also factors working the other way—importance of quality no backward integration—but these are not as strong.

Why is the market demand «challenging»?

The demand profile for the market is not clearly articulated, as mentioned in the structural assessment of this function. The market demand is described by several interviewees as highly volatile, and it is confirmed by NCA and NOFO that they usually buy equipment in bulk. Years may pass before they re-stock the same equipment, due to the longevity of the equipment and the (usually) low rate of use. This creates uncertainties in the market, and reduces the planning possibilities of sellers, which in turn increases the risk of investments in innovation.

Suppliers with a major part of their business in the OSR market see this as challenging, and emphasize the importance of international markets to maintain a steady income. For companies in which OSR is a smaller part of the business, this is less of an issue, as other markets bring steadier demand.

Another demand-related issue is that one sale often may generate further demand, both further sales and development collaborations. This is an added benefit to winning a contract. According to several interviewees, this is due to both experience effects—that the buyers have become familiar with the company—and the eventual need for upgrades or further development of equipment. The previously mentioned example H.Henriksen, has had Foxtail skimmers in use in the North Sea since 1984, and these are today represented on all NCA depots. H.Henriksen and NCA are now collaborating on the development of the AbsorbentBlaster, a technology for spreading absorbents on the shoreline.

Another issue is the purchasing processes. Most contracts are offered openly in the market, so previous sales should have little effect on the awarding of the next contract. How is it then possible that several interviewees describe the first sale as «getting the foot in the door»? This seems to be the buyer preference (mentioned briefly above) at work. NOFO will offer contracts to the selection of companies that are the most viable. These are often companies that the buyer has previous experience with. NCA emphasizes their use of tender in purchasing. However, there is a possibility of «circumventing» such processes. As an example, several interviewees have commented on the necessity of working their way into the specifications of these buyers. This seems to be a legitimate strategy for growth in this market.

An indication of the existence of such preferences, is the apparent need to «please» the buyers in the market. Most industry actors do in fact acknowledge that they are dependent on maintaining good relations with their buyers, NOFO and NCA. The reason given for this is that without such good relations, they will effectively be on the outside of the system. Good relations are a precondition for sales and collaborative developments, and comes with a range of benefits. NCA comments that this

EXAMPLE // Buyer preferences in the Norwegian OSR market


E24!

VILLEMANN VINJE

Innvandring som lønner seg

MARIUS GU

Den nye d

Ga bort oljevernkontrakter uten anbud

De samme selskapene som fikk selge statlig oljevernutstyr til BP i 2010, fikk åtte år tidligere servert gyldne, offentlige oljevernkontrakter - uten innblanding fra konkurrentene.

NYHETER Kristin Norli, Jo Andre Aakvik
Publisert: 11.05.2012 11:45, Oppdatert: 11.05.2012 11:45

An example of buyer preferences was recently published by the Norwegian business news site. According to their document sources, which have also been made accessible for the authors of this thesis, Norlense and AllMaritim may have accrued special benefits from their tight relations with NCA.

After the Macondo blowout, the need for OSR equipment in the Gulf of Mexico was precarious. Norlense contacted NCA for permission to sell oil booms (formerly supplied by Norlense) from the NCA depots. This was agreed to on the condition that Norlense would supply a matching amount of new oil booms. An industry actor has commented that this is «effectively evading government purchase regulations», in that Norlense was allowed to resell equipment and supply new equipment with no tender being held. According to E24, Norlense and AllMaritim made a total profit of 7 MNOK from this deal.

perception is unfortunate, and asserts that it is not the case.

Is there a market for services?

For the market for operational services, there is a weak market formation function. Actors in the Norwegian market have traditionally been equipment manufacturers, and this is the trend also in other parts of the world. In Norway, one reason for this is that the buyers have produced most of the operational services that are needed in their OSR planning, effectively limiting the market demand for services. Moving forward, the trends in energy extraction and transport may contribute to an increase in the demand for such services. They may also open for new areas of business in such services, e.g., solutions for organization of OSR, operational solutions, seminars, and training.

Why can an opening of a market for services be useful? There are several reasons. First of all, OSR is a market and basis for value creation in Norwegian firms. As is the case for equipment production, it may be favorable to let the market handle the production of OSR services and concepts. Innovation in services may be boosted by involving market forces to a larger extent than today.

Second, the major actors that handle service production today, NCA and NOFO, are not geared organizationally for taking economic advantage of this service production. Private companies would be able to generate services that could be tested and developed in Norway and then exported to other countries. The opening of such a market has been mentioned as a natural step further in the Norwegian market.

Third, a criticism towards NCA in the interviews is that they function as both a service producer and an oversight agency. It has been commented that this is a kind of role mixing that may produce sub-optimal results. This is disputed by NCA, which claims that the operational experience ultimately makes them a better oversight agency.

Is there any impetus for changing the system?

Taking the factors discussed above into account, are there any incentives to alter these framework conditions?

According to interviewees, the companies that find themselves on the «inside» of the system, i.e., are contract partners of the buyers, have no incentives to work for system change. There are limited opportunities for companies to voice concerns over the state of the market, as there is a threat of losing contracts due to such «activism». This holds also for the companies on the «outside» of the system. Change must then come from outside the industry and market itself. Politicians and advocacy groups may play a strong role here.

In summary, the function **does not work well.** There is a mature market for equipment, but it has serious issues related to strong buyer power. The nursing market for services is marginal. Change seems unlikely due to the troubles of voicing dissenting opinions.

Part 1 - Structural evaluation:

This function treats issues such as the strength of the legitimacy of the OSR technology, who influences legitimacy and how, and potential legitimacy's influence on demand, legislation, and other factors.

OSR has strong legitimacy in the Norwegian society. To determine this, two diagnostic questions have been posed: (1) Is there alignment between the OSR TIS and legislation, thereby giving legitimacy to the TIS, and (2) is there alignment between the value base in the industry and in the society? The answer to both questions is yes. OSR is required and supervised by several government authorities mentioned in chapter 2. It is also regarded by society as an integral part of oil exploration and production.

The legitimacy of the industry may be affected by the following factors:

Governmental actors such as NCA, Klif, and PSA pose requirements and follow-up. *Politicians* relay both the governing and the oppositional points of view. *Advocacy groups* such as Naturvernforbundet, Bellona, and Folkeaksjonen raise awareness of environmental or other consequences. *Experts* provide information on strengths and weaknesses of response. *The media* informs the public. *Major oil spills* such as Full City and Macondo test and reveal strengths and weaknesses of system and equipment. *Private companies* might choose to go beyond governmental requirements. Finally, the *vox populi*, apparent in the debate over Lofoten and Vesterålen, relays the public opinion.

Also contributing to the legitimacy is *how* governmental actors pose requirements. The requirements are defined as Best Available Technology (BAT), which means that the best products in the OSR industry are the official requirements. This increases legitimacy, as the industry products are seen as good enough to base requirements on.

Belief in the growth potential of the industry influences several functions, also legitimation. If there is an expectation of growth, it is legitimate to invest in these products and services. As such, the sustained growth over the recent years and DNV's acquisition of NPS lends legitimacy to the TIS.

The occurrence of major oil spills influences demand, legislation and firm behavior. After a spill there is oftentimes a debate on whether the response was sufficient and effective. This debate in itself also increases the legitimacy of the TIS.

The function *legitimation* is evaluated as **structurally fulfilled**. How well does the function perform?

PART 2 - FUNCTIONAL PERFORMANCE: Several of the structural factors mentioned above have been discussed already, such as governmental actors, oil spills, and experts such as Sintef. The existence of these factors positively affects the legitimation of the industry.

One of the other structural elements, the media, merits special consideration. A search on the term «oil spill response» (Norwegian: «oljevernberedskap») in the Norwegian news database Atekst turns out 1714 articles that include this term since 1972. Figure 10 in chapter 2.1 shows the distribution of these results. The use of the term peaks in certain years, clearly corresponding with the occurrence of major oil spills: 1989 (Exxon Valdez), 2002 (Prestige), 2007 (Server), 2009 (Full City), and 2010 (Macondo). Also, although the focus increases rapidly with an oil spill, it disappears just as quickly. This seems to confirm the famously short attention span of the media.

In total the term does occur more often over the recent ten years. This may imply that OSR is an issue that is becoming increasingly important, or that considerations are voiced more often than before. It may also be related to the number of ships running aground over the last decade.

Advocacy groups working specifically against oil exploration are vocal and receive media attention. An example is Folkeaksjonen, which attempts to mobilize the local population around Lofoten, Vesterålen and environs. But this group does not promote OSR, as their perspective is the preservation of natural resources specifically. The same is true for other conservationist advocacy groups such as Naturvernforbundet or Natur&Ungdom. However, there are also a few groups working on oil spill response, such as Bellona and Greenpeace.

The function is **working, but can be improved**. Advocacy groups are to some extent missing, and could be useful for influencing the media.

Part 1 - Structural evaluation:

This function treats issues such as the volume of available OSR capital, the volume and quality of human resources, and complementary assets. According to Hekkert *et al.* (2007:425) «resources, both financial and human capital, are necessary as a basic input to all activities within the innovation system».

The amount of total capital in the Norwegian OSR industry is relatively low, as is shown in table 3 in chapter 2.3. This is due to a limited market for OSR products. Table 7 (below) shows that the diversifying companies in general have larger revenues, and in turn more available resources, than the specialized OSR companies.

The potential buyer market has access to a potentially larger volume of capital. Available capital here is dependent on allocations from the government (NCA) and members (NOFO). NCA allocations are listed on page 30.

The government supports new companies and products through Innovation Norway and RCN, and NOFO does the same through the current program «Oljevern 2010». Venture capital is also available to some extent, as Norwegian OSR companies have a strong reputation globally. An example is Aptomar, which secured venture capital from among others Statoil Venture, ProVenture Seed, and Investinor.

In addition to capital, human resources are needed for a TIS to evolve. As a technological industry, engineers are considered an important human resource for the OSR industry. The overall quality of engineering education in Norway is considered to be high (Forskerforbundet 2008). There are also a few educational programs directly aimed at emergency response, including Societal Safety and Environment at UiT (Tromsø) and International Contingency at HiN (Narvik).

Company	Revenue	Diversifying / Not diversifying
Frank Mohn AS	2732750.00	Diversifying
Seaworks	194725.00	Diversifying
Aanderaa Data Instrument (Aadi)	152188.00	Diversifying
AllMaritim AS	91850.00	Not diversifying
NOFI	88195.00	Diversifying

Table 7: Top 5 companies by revenue. Four out of the five top five companies are defined as diversifying companies.

Another factor that affects resource mobilization is to what extent the TIS can mobilize complementary assets, including complementary products, services, network infrastructure et cetera. The TIS has some complementary assets to draw on. NOSCA promotes the Norwegian OSR abroad and serves as a knowledge base for supply companies. AllMaritim is a wholesaler company that markets and sells equipment for OSR companies. There are also cluster development projects such as Arena Beredskap. All these have knowledge and networks that are considered complementary assets for companies in the Norwegian OSR industry.

The function *resource mobilization* can be evaluated to be **structurally fulfilled**. How well does the function perform?

Part 2 - Functional performance:

The main issues that must be evaluated here are the availability of capital and other available resources, and the incentives for such resource mobilization.

There is some capital in the OSR industry, but little to mobilize for innovation purposes. Survey results show that companies spend on average about 10 percent of revenues on innovation, a figure that is not inadequate in itself. But taking into account that firms are small, the volume of capital available for innovation is also quite small. An estimated total figure for the 16 companies surveyed in this thesis is somewhere between 45 and 60 MNOK per year.

The buyers have a potentially large volume of capital available. But the willingness to spend this capital on OSR development is relatively low, according to interviewees. NCA invests to little extent financially in OSR development. NOFO is constrained by its funding members. Both established actors and new ventures point out that the amount of available funding is too small. Capital might be available from outside investors, however, it has been commented in interviews that the market conditions are strong deterrents.

Although the existence of government grants *per se* is a positive contribution to this function (Hekkert *et al.* 2007), the financial support available is only general grants that all kinds of technology projects may apply for. This is deemed insufficient by interviewees. Also, the research shows that grants given to OSR go solely to projects in the industry. Although this may result in new development, funding of researcher projects (chapter 2.5) should also be considered.

Other available resources include human resources and complementary assets. The technical university education in Norway of high quality, but the volume of available resources is low (figure 29). The complementary

FOTO: TIM PANNELL/CORBIS/SCANPIX

Ingeniørmangel stopper hjulet

Norge mangler 16 000 ingeniører. Det er en dobling siden i fjor. 7 av 10 kommuner tror de vil miste flere av sine tekniske eksperter, særlig fordi unge heller vil jobbe i privat sektor med høyere lønn. Konsekvensene er treg saksbehandling, ubygde hus og dårligere veier. Side 2 og 3

Figure 29: 12th February 2012, Aftenposten writes that there is a shortage of 16 000 engineers in Norway (ATEKST.NO).

assets found in the Norwegian OSR industry are few, but both NOSCA and Allmaritim fill important roles and are considered to be complementary assets for TIS. Cluster development projects such as Arena have so far not made a big impact on the market.

This evaluation has so far shown that the opportunity to mobilize resources is constrained. To fully explore this function (SWANN 2009), another question must also be asked: What are the incentives to mobilize resources for innovation in OSR?

The expectation of future profit is normally the driver of innovation. For the companies in the *OSR industry*, this is true. However, factors such as the volatile market demand increases uncertainty and limits such incentives.

For the *oil industry and NOFO*, there is no profit incentive connected to investment in OSR products or services. One could also argue that an investment in better OSR technology would radically reduce the cost of a possible oil spill cleanup. But such a link between investment in OSR technology and savings connected to cleanup of a spill does not exist, according to ENI and Statoil.

Also, few incentives have existed for exceeding any minimum governmental requirements. The oil industry in Norway has traditionally operated far from land, where the oil companies and NOFO will have time and resources to clean up a spill. This will change as the oil industry moves closer to the coast. Shorter distances increase the possibility that an oil spill will reach the coast, which in turn provides fresh incentives for the industry to invest in OSR.

For *NCA*, there are strong reasons to be directly involved in OSR development. As was mentioned in chapter 1.3.4, the oil spills in recent years have mainly come from ships running aground. Ship traffic represents the strongest strain on the Norwegian coast (Bellona.no 2012). The government also has needs differing from those of the oil industry: shipwreckings demand quicker response, and a response adapted to coastal conditions.

Therefore, the fact that the Norwegian government has handed over the responsibility for innovation in this industry—when it has such major tasks to handle itself—is quite surprising. Although it is commented that the coverage areas of OSR are increasingly similar, it has not been this way until in the most recent years, leaving a gap back to the last government-run program in 1993.

Here, it should be pointed out that this is not the consequence of failings of NCA. This is a result of political priorities. Increasing government involvement in the national security issue of OSR is therefore also an issue that must be addressed politically.

Additionally, the shipping industry is likely to comply only with the minimum OSR requirements. As P&I insurance covers claims after an accident through an insurance pool, the shipowner or -operator will not be presented with the full cost of the accident. In turn there is no direct economical link between investments in OSR equipment and possible cost reductions.

The function **does not work well**. Although the structural elements are in place, resources are hard to mobilize. Incentives are skewed, resulting in a lack of financial resources mobilized to further development of OSR technology. Human resources are good but scarce, and complementary assets are few.

Part 1 - Structural evaluation:

This function includes the positive externalities that may arise in a TIS. Such factors are legitimacy, information and knowledge flows, specialized intermediates, political power and other aggregate level issues.

Legitimacy was described in chapter 6.1.5. The function is working as a result of, among others, alignment with legislation and alignment between value bases of the industry and the society, and that there are a number of actors positively contributing to the legitimation of the TIS.

Another factor is information and knowledge flows. Networks have developed, which can relay information among firms. One such network is the industry association NOSCA. Another network is the attempted cluster development Arena.

A third factor is the development of specialized intermediates. One of these is the distributor AllMaritim, which has acquired marketing and promotional skills needed for wider distribution. AllMaritim also has a strong network with NOFI and Norén, whose products it distributes. Also NPS, MMB, and Arctic Protection are such intermediates, selling the use of equipment and know-how.

There is another externality that one might have expected to appear in the mature market of this TIS. This factor is political power, which does not seem to exist for the OSR companies. On the buyer side, NCA possesses some political power through the role as an oversight agency. NOFO as a knowledge organization surely also possesses some political capital, even though they dismiss completely any political role.

The function *development of positive externalities* is evaluated to be **partially fulfilled**. How well does the function perform?

Part 2 - Functional performance:

It should be noted that this function is to a large extent linked to and dependent on the other TIS functions. If they are not fulfilled, then the development of positive externalities will not be fulfilled either. The externalities that have developed—legitimacy of the industry, information flows, and a few specialized intermediates—are working. But, as this is a mature market, one might have expected externalities to develop stronger.

One would also expect a development of political influence on the supplier side, such as the ability to raise a debate on the organization of the system, or pressure local and regional elected representatives to do so. However, this does not seem to be the case, as interviewees lament the fact that they have no way to speak up and maybe change the system.

However, the Norwegian market is small, both in number of actors and revenue. This is a limiting factor for the development of positive externalities.

The function is **working**, but can improve along with the development of other functions. Few positive externalities have developed for the system over the last four decades.

6.1.8 Summary of the discussion of functions

Summarizing the structural fulfillment, two functions are only partially fulfilled, while the five other functions are considered fulfilled.

Summarizing the functional performance, there are three functions that are not functioning sufficiently (F1, F4, F6), while there are four functions that are working well or working but may be improved (F2, F3, F5, F7). Thus, structural fulfillment does not necessarily result in functional performance. The results are further discussed in the following chapter.

6.2 How does the analysis fit with the expectations?

After this detailed analysis of the TIS functions, the empirical evidence must be compared with the expectations outlined in the end of chapter 3. Are the expectations confirmed or disproved?

(1 & 2) How do the TIS functions contribute to the TIS?

Expectation 1 was that the functions *influence on the direction of search, legitimation,* and *resource mobilization* affect the TIS positively.

Expectation 2 was that *knowledge development and diffusion, entrepreneurial experimentation, market formation,* and *development of positive externalities* affect the TIS negatively. What can be concluded after the preceding analysis?

Chapter 6.1 concluded that *influence of the direction of search* is well functioning and affects the TIS positively. The functions *entrepreneurial*

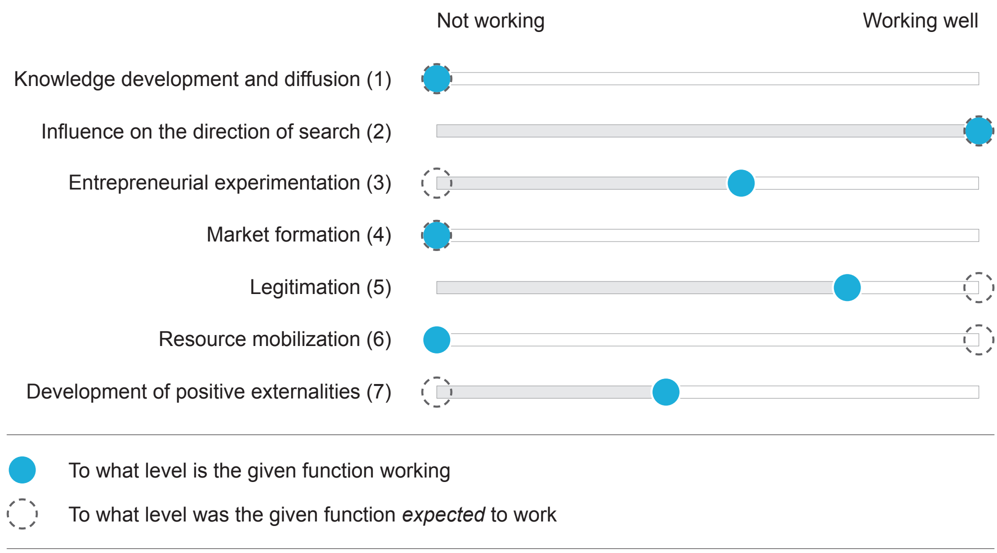


Figure 30: Comparison of expectations and findings of functional performance.

experimentation, *legitimation*, and *development of positive externalities* are working but all have room for improvement. *Knowledge development and diffusion*, *market formation* and *resource mobilization* are functions that are not working well and influence the TIS negatively.

The findings relative to the expectations are shown in figure 30. The figure shows that functions 1, 2, and 4 performed as expected. The functions 3, 5, and 7 vary somewhat from the expectation. Function 6 directly contradicts the expectation.

(3) Do macro-level features of OSR contribute to innovation positively?

Expectation 3 was that there exist macro-level features of OSR which have a positive contribution to innovation. These can be seen as contributors to the external forces that drive innovation (Kline & Rosenberg 1986).

Although OSR is a task of national security, innovation in the industry is left to the OSR and oil industries alone. Therefore, there is no positive contribution to innovation from this specific feature. There does exist a research program under RCN, but support is hard to obtain. There are also resourceful stakeholders in the industry, but again, skewed incentives make resources hard to mobilize.

In addition, interviewees emphasize that an investment in OSR is purely a cost. For the private oil industry there is no possible profit generation in OSR that incentivizes development. For NCA there is little opportunity to push for more than steady and continuous development, in accordance with their funding and ten-year analyses of the Norwegian response system. In addition, the OSR analyses of NCA are based on current solutions and known technology. The result of this seems to be slow and incremental development.

In summary, the findings *do not correspond with the expectation.*

(4) Do governmental regulation and support schemes contribute to OSR innovation positively?

Expectation 4 was that the presence of government in OSR has a positive impact on innovation through regulation and support. These are the two major roles identified in literature on government involvement in innovation (Kemp 2000, Porter 2000, Carlsson 2006).

Governmental regulations are, along with the occurrence of actual oil spills, highlighted by most interviewees as the most important innovation drivers in the OSR market. Several interviewees do however characterize today's regulations as too soft, calling for stricter and more specific requirements.

The support schemes are also drivers of innovation. RCN and Innovation Norway are the main sources for grants, but it is a common opinion that the competition for these grants is stiff. Another issue is that the grants mostly go directly to projects in the OSR industry—none of the supported projects are pure researcher projects (chapter 2.5.1). This may contribute to less radical innovation.

The empirical findings *correspond to some extent with the expectation.* Regulations and requirements are very important for OSR innovation. Support schemes also contribute, but the allocations of funding in the schemes are criticized.

(5) Does concentrated buyer power limit the sellers' contribution to innovation?

Expectation 5 was that NCA and NOFO exploit their bargaining power towards sellers, causing under-investment in innovation. This is the classic *hold-up problem* identified in literature (Huang & Sexton 1996). Also, a lack of secure returns on investment constrains the *incentive* to innovate, which is the *first* of two forces that differ depending on market structure (Swann 2009).

Is there a hold-up problem in the OSR industry? The existence of the development program «Oljevern 2010» could imply some degree of hold-up. In this initiative, the buyers carry the full cost of development of new projects, which in theory is the suggested solution for a hold-up situation. However, it does not seem that hold-up is the case, as OSR companies in fact do invest in R&D (table 4 in chapter 2.3). With some innovation happening in the industry and the existence of buyer-financed development, the issue of hold-up may be set aside.

An issue that has been raised in interviews is the volatile market demand, with large contracts arriving at irregular intervals. This implies highly uncertainty on returns on investment, which limit the incentive for long-term development. It also becomes a source of bargaining power. With few buyers, dependency issues arise. The sellers depend on selling the equipment they develop, and maintain that keeping close contact with the buyers, effectively developing what the buyers want, is a widespread strategy. This enables development of products for which the need is already established, thereby increasing the possibility of closing a sale. The result of this dynamic is that new products to a large extent are based on existing solutions, which in turn promotes incremental innovation.

Another issue is that there seems to be a divide between companies on the inside and on the outside of the system. The insiders have typically supplied the buyers for a number of years, which brings experience and better knowledge of the needs of the buyers, but may also bring complacency and a lack of drive for new experimentation. Therefore, the concentration of buyers may indirectly influence the sellers' contribution to innovation.

The empirical findings do not identify a hold-up problem. However, they identify other issues that *correspond well with the expectation.*

(6) Does the way the buyers are funded limit the buyers' contribution to innovation?

Expectation 6 was that the funding sources of buyers affect their contribution to development negatively. Lack of funding constrains the opportunity to innovate, which is the *second* of two forces that differ depending on market structure (Swann 2009).

IUAs are funded on the basis of population density. This scheme favors the IUAs of major cities instead of IUAs with specific response challenges or with longer and more vulnerable coastlines. Interviews confirm that small IUAs spend most of their funds on training of key personnel, and therefore have little left over for investments.

NCA is funded over the national budget, and is subject to the fleeting attention of politicians. Interviews confirm that the base funding for innovation of 9 MNOK must be augmented with parliamentary earmarked appropriations for more costly investments, such as the 15 MNOK granted for IUA upgrades in 2012.

NOFO is funded by its member oil companies, which are in general interested in keeping costs low. Cost is one of the major arguments for managing OSR in a single organization. Interviews confirm that OSR related to Goliat, which goes beyond today's requirements, has been subject of debate among NOFO participants.

Thus, the IUAs, NCA, and NOFO may all have incentive to contribute to innovation, but the funding schemes seem to limit their opportunity to do so. In the TIS model, these funding issues are grouped structurally under resource mobilization. The issues do however affect several other functions, such as the direction of search and entrepreneurial experimentation.

The empirical findings *correspond well with the expectation.*

(7) Where are opportunities in the OSR industry to be found?

Expectation 7 was that there are still opportunities to be found in OSR equipment production, even though that is the area where most Norwegian OSR companies are active today.

Research suggests that the major opportunities in Norwegian OSR are found in mechanical recovery and remote sensing. This is where most money is made, and is aligned with buyers' needs.

A specific area of development in mechanical recovery that should be pursued is equipment for Arctic challenges, due to the increasing activity in the High North. Equipment developed for icy waters would be of use also other places, e.g., the Oslo fjord. Another market that may be viable is the market for dispersion equipment and dispersants. NCA states that dispersants will become an increasingly important part of Norwegian OSR, but for now this market is still limited.

However, the state of the Norwegian OSR market limits the possibility to argue convincingly of future opportunities. The preceding discussion has revealed deficiencies in the market, both a lack of innovation drivers and a strong buyer power, and this functioning of the market makes it increasingly difficult for any actor in the market to plan future developments. One such development could be in OSR services. However, interviewees comment that fundamental change at NOFO and NCA is needed in order for this to happen.

As long as the market structure remains at status quo, the opportunities in the Norwegian OSR industry are found in equipment production. The empirical findings *correspond well* with the expectation.

Summary of expectations

In summary, expectations 5, 6, and 7 are corroborated by the findings. The expectations 1 and 2 of the TIS functions, and expectation 4, are to some extent corroborated by the findings. Expectation 3 is not corroborated by the findings.

important issues beyond the expectations

Apart from the empirical findings linked to expectations above, some findings appeared that were not expected.

One of the issues most discussed in the interviews was the role and workings of NOFO. It is remarkable how opinions vary based on the specific interviewee's relationship with NOFO. Suppliers and other actors that have a good relationship with NOFO, effectively «inside» the NOFO system, express positive opinions. Actors on the «outside» of the NOFO system express mostly negative opinions and criticize many different aspects of NOFO including the structural system, buying processes and its attitudes towards supply companies and potential competitors. Some of these opinions are also directed towards NCA, but not to the same degree as NOFO.

A recurring issue is that the interviewees that have expressed strong opinions about NOFO and/or NCA have also requested to be anonymized. The reason for this is the same for all respondents. They are utterly dependent on NOFO and/or NCA as a customer, and cannot afford to risk their relationship with these buyers. The fact that several actors in the industry are critical to the market structure, but do not dare to express it, may be an important factor in the market.

It has also been commented that system change will not happen if not the need for such change is expressed by a united OSR industry. As the situation is today, this will not happen, as the suppliers on the «inside» of the system have little incentive to work for change.

6.3 Main inducement and blocking mechanisms in the OSR market

Bergek *et al.* (2008) recommends distilling the findings from the discussion into the main mechanisms that affect the TIS. These can be positive inducement mechanisms or negative blocking mechanisms. Also included, under the first blocking mechanism, is an example of cumulative causation. Such causation is valid for all mechanisms, but it has been considered adequate to elaborate on one example.

6.3.1 Inducement mechanisms

The inducement mechanism that has been mentioned by most interviewees is *governmental requirements*. The role of government in the development of OSR cannot be emphasized strongly enough. OSR is clearly a task of national security and safety. Thus, the government plays an important role in their demands towards the polluting actors. Such requirements influence several functions: knowledge development, influence on the direction of search, legitimation, and resource mobilization.

The other main inducement mechanism that has been mentioned by most interviewees is the *occurrence of oil spills*. The effect of this mechanism has been apparent after recent spills. How strong the effect of this inducement mechanism is, seems to depend on three factors: the time elapsed since the previous spill, the size of the spill, and the distance to the spill. An oil spill that happened recently, was large in size, and close to Norway provides a strong inducement mechanism. Comparatively, a recent and large spill that happens on the coast of Africa will not be as strong a mechanism. The functions that are affected are mainly the knowledge development, influence on the direction of search, entrepreneurial experimentation, legitimation, and resource mobilization.

The *belief in future market growth* is a prevalent inducement mechanism, as it is in most industries. Optimism among Norwegian companies due to recent market growth strengthens the functions of entrepreneurial experimentation, market formation, and resource mobilization.

Development projects run by major buyers affect the functions in the TIS. It has a direct effect on knowledge development and the direction of search, and the existence of such projects promotes entrepreneurial experimentation.

Trends in energy production and transport were a part of the background for this thesis, discussed in chapter 1.3. According to interviewees, such trends are considered positive for development. The expectation of increases in energy production and transport influences the direction of search.

6.3.2 Blocking mechanisms

The blocking mechanism that has been mentioned the most by interviewees is that there are *few, strong, and large buyers* in the market. A direct effect of this is that sellers depend on maintaining good relations with the two main buyers, which control what is described as a strategically important home market, and further market formation. As discussed in chapter 6.2.4, buyers build specifications for requested equipment, for which the industry develops. This creates a dynamic that negatively affects experimentation and the direction of search, in turn knowledge development, and may induce negative *cumulative causation* (figure 31).

Another strong blocking mechanism is the *volatile and poorly articulated demand*. Uncertainty envelops the OSR market and increases the risk of investments in innovation. Volatility may drive external investors away and deter new entrants. This blocking mechanism affects the direction of search, entrepreneurial experimentation, market formation, and resource mobilization.

A third buyer-related mechanism relates to the *buyers' funding of investment*, which affects the TIS functions. NCA has a low base funding that allows little investment. NOFOs members decide together what the organization should invest in. IUAs have in general little resources for investment. These limits affect functions such as knowledge development and diffusion, and resource mobilization.

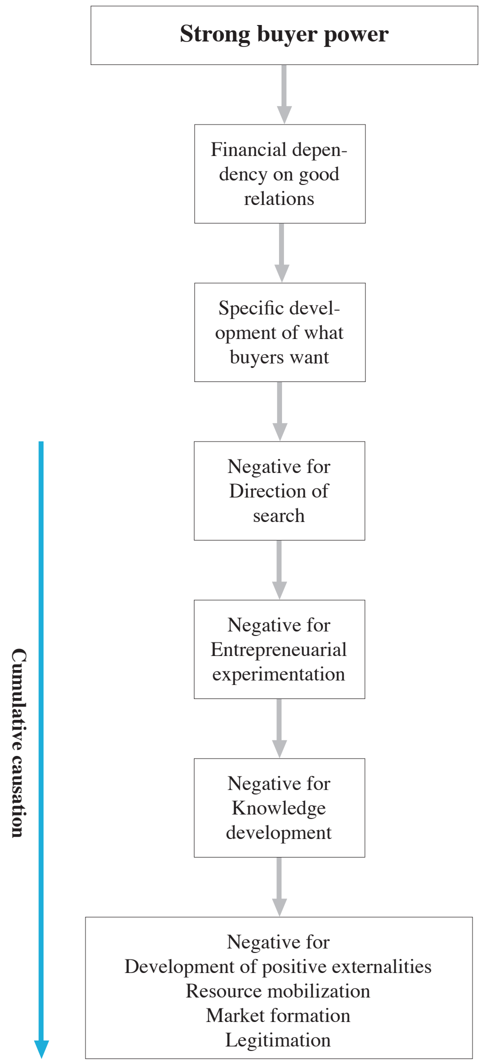


Figure 31: Possible negative cumulative causation due to strong buyer power.

The *missing link between OSR investment and possible savings* is the source of another blocking mechanism. As for the previous function, it affects mainly knowledge development and diffusion, and resource mobilization.

The *occurrence of oil spills* is mentioned above as an inducement mechanism. It may also become a blocking mechanism. If a long time has elapsed since the previous incident, the size of recent spills have been small, and they in general have been far away, then this may become a pretext for making less and less effort in OSR. As the corresponding inducement mechanism, this affects the knowledge development, direction of search, entrepreneurial experimentation, legitimation, and resource mobilization.

The last of the major blocking mechanisms is the *strong competition for government funding*. For many industries, government funding would certainly be an inducement mechanism, however hard it would be to attain it. The argument here is that by the very fact that the government has such strong interests in a well-functioning OSR, then the financial support available through general grants for all kinds of technological progress is insufficient. The strong competitive element affects functions such as knowledge development, entrepreneurial experimentation, and resource mobilization.

In summary, there are a number of inducement and blocking mechanisms that affect the workings of this technological innovation system. They are summarized in figure 32.

6.4 Summary

This chapter has analyzed the performance of the Norwegian OSR market as a TIS, concluded whether or not the the expectations stated in chapter 3 were correct and identified the main inducement and blocking mechanisms that affect the TIS functions. The next chapter will identify the essential findings and suggest measures in order to strengthen innovation in the Norwegian OSR market.

Function is induced by:	Function	Function is blocked by:
Occurence of oil spills Governmental requirements	Knowledge development and diffusion	Buyers’ funding of investments Missing link between OSR invest-ments and possible savings Occurence of oil spills Strong competition for gov. funding
Governmental requirements Trends in energy and transport Occurence of oil spills	Influence on the direction of search	Volatile and poorly articulated demand Occurence of oil spills Few, strong and large buyers
Belief in future market growth Projects run by major buyers Occurence of oil spills	Entrepreneurial experimentation	Few, strong and large buyers Volatile and poorly articulated demand Strong competition for gov. funding Occurence of oil spills
Belief in future market growth	Market formation	Few, strong and large buyers Volatile and poorly articulated demand
Occurence of oil spills Governmental requirements	Legitimation	Occurence of oil spills
Occurence of oil spills Governmental requirements Belief in future market growth	Resource mobilization	Volatile and poorly articulated demand Buyers’ funding of investments Missing link between OSR invest-ments and possible savings Strong competition for gov.funding Occurence of oil spills
	Development of positive externalities	The function is dependent on the other six functions as explained in chapter 6.1.7.

Figure 32: The mechanisms that induce and/or block the different functions.

7 Key issues, actions, and implications

The previous chapter discussed the fulfillment and performance of the TIS functions of OSR, and identified important mechanisms that induce or block innovation.

This chapter recapitulates the essential findings, and suggests how policy can address the issues that have arisen. Six key actions are defined in order to establish drivers for innovation and reduce the buyer power. However, it is beyond the scope of this thesis to formulate specific policy proposals.

7.1 The essential findings

There are two overall features that stand out as main sources for the system failure in the Norwegian OSR market: a *lack of innovation drivers*, and a *strong buyer power*. These features seem to be the main sources for the system failure in the Norwegian OSR market.

The lack of drivers becomes apparent when looking at the the incentive and opportunity to innovate for the three groups of stakeholders.

The *sellers* have neither opportunity nor incentive to invest in long-term development. They have little economic resources, and the volatile market demand limits the incentive for investing in development projects with uncertain outcomes.

The *buyers*—NOFO and NCA—have a varying degree of incentive to innovate, but limited opportunity. Both organizations' opportunities are financially constrained by their «owners».

The *end users* have limited opportunity and incentive to innovate. The opportunity is constrained by strong cost-benefit evaluations, and the incentive is limited by unspecific governmental requirements.

The second characteristic that has major influence on the OSR market is *strong buyer power*. One of the most unexpected and interesting findings was that industry actors are extremely cautious of criticizing the major buyers. Almost without exceptions, the critics wanted to be anonymous.

This struggle to become an «insider» with NOFO or NCA is a distinct feature of the Norwegian OSR market. A strategy here is becoming the «specification» or the BAT-requirement from Klif.

The OSR industry does to a large extent base their product development on buyers' demand, a demand that in turn is based on existing products. This is one factor that induces incremental innovation. Another factor is the unclear demand profile.

In summary, it should be clear that the lack of innovation drivers combined with effects of strong buyer power has resulted in a market that does not encourage innovation. Chapter 7 will suggest possible solutions and changes that can be done in order to create a more well functioning OSR market.

7.2 Key actions

Key action 1: Increase and better specify OSR requirements

In accordance with the priority of the interviewees, the first recommendation is a strengthening of the OSR requirements by the government (Klif). This could be a general increase on certain issues, such as coastal preparedness, or it could be targeted for specific parts of the industry.

In any case, requirements must be shifted from an emphasis on BAT—which is not very specific—towards more targeted demands. This can be achieved by introducing a certification scheme for OSR products, which could categorize and qualify equipment on better grounds than what is done today. Such a scheme is currently being researched by Sintef and DNV.

Key action 2: Open for direct financing of innovation by NCA

As argued in 6.1.6, NCA has specific needs that must be filled in their task of maintaining coastal security. Oil spills from ships differ from oil spills from oil installations: the oil is a heavier type of oil (bunker oil), and the spill itself happens close to the coast. Here, the government cannot only lean on solutions from the oil industry. They need oil booms for quicker response, oil booms that can handle stronger currents, skimmers that handle heavy oil effectively, and dispersants that can be used near the coastline without damage to marine resources. Some of these specific needs are in fact mentioned in the 2011 EPA.

Specifically, as grants usually are given on a year-to-year basis, direct and long-term fundingof innovation by NCA requires an increase in the base funding by Parliament.

Key action 3: Improve conditions for research funding through RCN

There is strong competition for funding of OSR projects from other technology areas. Earmarking funds over a certain period of time could induce development of new projects in this field. Making new OSR development a priority would be coherent with the Technology Target Areas (TTA) strategy of the oil industry strategy group OG21. OSR could also become part of a national effort for increased contingency planning. Such an effort could create expectations of growth in the market for years ahead, possibly inducing other investment in the market.

Key action 4: Incentivize further developments from the oil industry

Some OSR development is happening in the oil industry. However, interviews have established that many of these developments are dropped, as the efficiency of the technologies do not live up to internal criteria for commercialization. Further development, and commercialization, must be further induced. As commented both by Sintef and Arctic Protection, there is no profit motive for the oil industry in OSR, and no link between investment and possible savings. If deemed politically acceptable and effective, such a link could be established, e.g., by publicly prioritizing—in future concession awardings—oil companies that have a good record with OSR development.

Key action 5: Strengthen IUAs in general

The regional OSR is weak, as many IUAs lack funding and are based in general on local emergency responders, e.g., the fire brigade. This system needs a reorganization, which can be increasingly professionalized and based on a task force model, such as IGSA. With better-trained people and increased funding, IUAs could become a source of demand for new solutions that are more tailored to local and regional conditions. Examples are specific developments for the Lofoten islands, which have strong tidal currents, and the coast of Finnmark, of which vast areas are uninhabited.

Key action 6: Reduce NOFO's role in the market

The strong buyer power in the OSR market must be addressed. An organizational change in NCA seems unlikely, and not necessarily suitable. Rather, a reduction in the role of NOFO could be attempted.

From a pure market perspective, a dissolution of NOFO is arguably the best option. NCA could then divide the coast into response zones and invite private operational companies to seek operating concessions. Such a division of responsibilities would effectively reduce buyer power, as oil companies would contract directly with operational companies in the relevant zone(s), which in turn would request equipment and services in the OSR market.

A dissolution of NOFO is however an unrealistic option, due to the satisfaction with the current system. A more realistic option would be to reduce NOFO's role, specifically in the area of OSR concept and services production, hence, an opening of this market. Increasing demand in this area, may induce entry of new companies, and a possibly profitable export of Norwegian OSR concepts. The buyer power would also be reduced, as new operational companies would become equipment buyers as well.

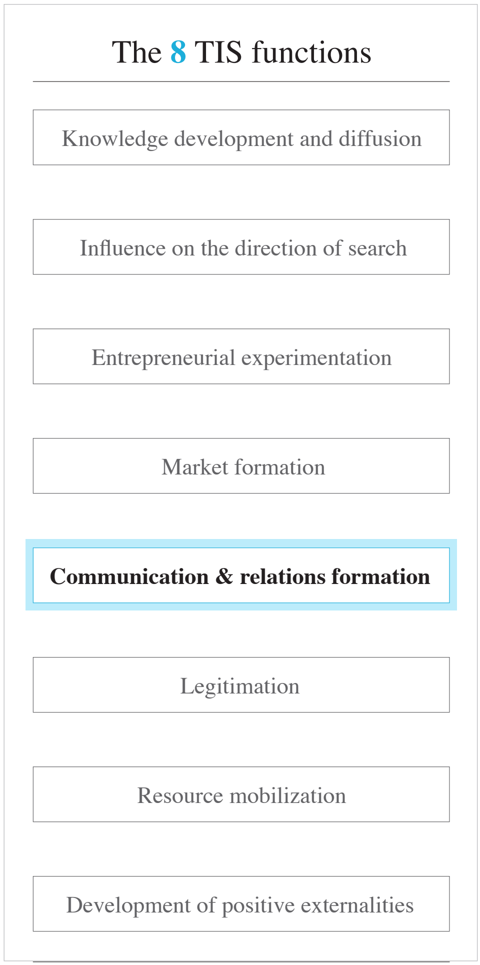


Figure 33: An updated list of TIS functions.

7.3 Further research

This chapter will briefly discuss further research in the area of OSR, and how further theoretical research on technological innovation systems can be informed by this OSR case study.

7.3.1 OSR research

There have been written no comprehensive reports on framework conditions in the Norwegian OSR market that the authors know of. Taking into account the overwhelmingly positive feedback from the OSR industry on this thesis' problem statement, it is reasonable to conclude that such an investigation has not been carried out. A report on framework conditions could build on issues identified in this thesis, such as the effects of concentrated buyer power and lack of innovation drivers. It should also touch upon funding issues and communication issues. With the trends in energy exploration and transport fresh in mind, it may seem that the time is nigh for a deeper exploration of the mechanisms that drive, or hinder, innovation in Norwegian OSR.

Another research issue to consider is a follow-up of the results of the NOFO project «Oljevern 2010». How many of these projects were successfully commercialized? Why did some succeed and others not? Such an investigation could provide new insights into the dynamics of the Norwegian OSR market.

7.3.2 Theoretical research

The TIS model and its functional perspective have brought interesting new perspectives into the innovation systems literature. Through the analysis in this thesis, where the structural fulfillment did not necessarily translate into optimal performance, it has shown its scientific value.

In this thesis there also arose an issue that did not fully fit into the model. This issue was the OSR industry's apprehension of criticizing the market structure and the consequences of buyer power. This is not a structural matter of lack of networks. It is a matter of how the networks are functioning. This could be further researched in another framework, e.g., a psychological and/or sociological framework.

It is proposed that the issue of *communication & relations formation* should be researched as a possible addition to the list of TIS functions. This function is not merely a matter of actors' market strategy or information and knowledge flows, as is discussed under the functions market formation and development of positive externalities, respectively. Communication and relations are pervasive to the whole system. It may be shown to have strong links also with the function influence on the direction of search.

8 Concluding remarks

This thesis has addressed industrial opportunities in Norwegian OSR, and how innovation can be strengthened. From the preceding discussion, it is clear that the innovation system of OSR has serious deficiencies.

Industrial opportunities in OSR are limited by the current market structure, as innovation drivers are few and weak, and buyer power is strong. The reluctance of actors to criticize the major buyers due to fear of possible negative consequences is a clear sign of dysfunction. In addition, the governmental regulations—which the industry strongly depends on—are nondescript. These market issues have resulted in 20 years of limited innovation, marginal presence of private suppliers of OSR services and operations (besides NOFO), and little market development.

It is the authors' opinion that before future opportunities can be identified, the current deficiencies in the Norwegian OSR market must be solved. The key actions identified in chapter 7 aim to facilitate industrial opportunities by enhancing innovation drivers and reducing buyer power. These actions can be a first step in the development of a well-functioning Norwegian OSR market, which is a prerequisite for a credible claim to the «best oil spill response in the world».

9 References

Asheim (1996): Industrial districts as «learning regions»: A condition for prosperity? European Planning Studies, 4, 379-400.

Atekst.no (2012): Statistics on search term "oljevernberedskap".

Avisa Nordland (2009): "Kritisk til lokal beredskap". 5. August 2009. *http://www.an.no/nyheter/article4500476.ece*

Bambulyak & Frantzen (2009): Oil transport from the Russian part of the Barents region. Status per January 2009. The Norwegian Barents Secretariat and Akvaplan-niva, Norway.

Barents Observer (2011): More traffic along the Northern Sea Route. *http://www.barentsobserver.com/more-traffic-along-the-northern-sea-route.4947500.html*

Bellona (2010): Faktaark: Oljevernberedskap. *http://www.bellona.no/factsheets/1138835039.25*

Bergek, Jacobsson, Carlsson, Lindmark & Rickne (2008):Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy, 37, 407-429.

Breschi & Malerba (1997): Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries. In: Edquist, C. (ed.), Systems of Innovation – Technologies, Institutions and Organizations, 130-156. London: Pinter.

Carlsson (2006): The role of public policy in emerging clusters. In: Braunerhjelm & Feldman (Eds.) Cluster Genesis: Technology-based Industrial Development. Oxford: Oxford University Press.

Carlsson (Ed.) (1997): Technological systems and industrial dynamics. Boston: Kluwer Academic Publishers.

Carlsson & Stankiewicz (1991): On the nature, function and composition of technological systems. Journal of Evolutionary Economics, 1, 93-118.

Carlsson, Jacobsson, Holmén & Rickne (2002): Innovation systems: analytical and methodological issues. Research Policy, 31, 233-245.

Cooke & Morgan (1993): The network paradigm – new departures in corporate and regional development. Environment and Planning, 11.

Cooke *et al.* (1998): Regional innovation systems: designing for the future. Final report to the European Commission.

Dagsavisen (2010): "Forbereder seg på oljekatastrofe". 29. April 2010. Downloaded from atekst.no

DSB (2011): Direktoratet for samfunnssikkerhet og beredskap. Interkommunalt utvalg mot akutt forurensing.
http://www.dsb.no/no/Ansvarsomrader/Brannvern/Brann-og-feiervesen/IIUA/

DTI (2006): 60 minute guide to innovation – turning ideas into profit. Department for Trade and Industry. Downloaded from:
http://www.bis.gov.uk/files/file34902.pdf

E24.no (2012): "Veritas kjøper oljevernselskap". 30. April 2012.
http://e24.no/olje-og-raavarer/veritas-kjoeper-oljevernselskap/20199110

Edquist & Johnson (1997): Institutions and organizations in systems of innovation. In: Edquist (Ed.), Systems of Innovation – Technologies, Institutions, and Organizations. London: Pinter.

Edquist, C., Malerba, F., Metcalfe, S., Montobbio, F., Steinmueller, E., (2004): Sectoral systems: implications for European innovation policy. In: Malerba, F. (Ed.), Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe. Cambridge University Press, Cambridge, pp. 427–464.

Feldman (2000): Location and innovation: the new economic geography of innovation, spillovers, and agglomeration. In: Feldman, Clark, Gertler (Eds.), The Oxford Handbook of Economic Geography, 373-394. Oxford University Press: Oxford.

Freeman (1987): Technology Policy and Economic Performance. London: Pinter.

Fylkesmannen (2011): Fylkesmannen i Troms, Samfunnssikkerhet og beredskap.
http://www.fylkesmannen.no/hoved.aspx?m=3843

Gautier *et al.* (2009): Assessment of Undiscovered Oil and Gas in the Arctic. Science, 324, 1175-1179

Hall & Kerr (2003): Innovation dynamics and environmental technologies: the emergence of fuel cell technology. Journal of Cleaner Production 11, 459-471.

Hekkert, Suurs, Negro, Kuhlmann & Smits (2007): Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting & Social Change, 74, 413-432.

Huang & Sexton (1996): Measuring Returns to an Innovation in an Imperfectly Competitive Market: Application to Mechanical Harvesting of Processing Tomatoes in Taiwan. American Journal of Agricultural Economics, 3, 558-571.

IEA (2011a): World Energy Outlook. Executive Summary.
http://www.iea.org/weo/docs/weo2011/executive_summary.pdf

IEA (2011b): World Energy Outlook. Presentation to the press.
http://www.iea.org/weo/docs/weo2011/homepage/WEO2011_Press_Launch_London.pdf

Innovation Norway (2012): About us.
http://innovasjonnorge.no/Contact-us/

ITF (2011): Transport Outlook: Meeting the needs of 9 billion people. International Transport Forum.
http://www.internationaltransportforum.org/Pub/pdf/11Outlook.pdf

ITOPF (2008): Country Profiles. A summary of oil spill response arrangements and resources worldwide. The International Tanker Owners Pollution Federation.
http://www.itopf.com/information-services/country-profiles/

Jacobsson & Bergek (2004): Transforming the Energy Sector: The evolution of technological systems in renewable energy technology. Industrial and Corporate Change 13(5): 815.

Jacobsson & Bergek (2011): Innovation system analyses and sustainability transitions: Contributions and suggestions for research. Environmental Innovation and Societal Transitions (in press).

Jacobsson & Johnson (2000): The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy, 9, 625-640.

JD (2002): St.meld. nr. 17 (2001-2002). Samfunnssikkerhet: Veien til et mindre sårbart samfunn.
http://www.regjeringen.no/Rpub/STM/20012002/017/PDFA/ST-M200120020017000DDDPDFA.pdf

JD (2004): St.meld. 39 (2003-2004). Samfunnssikkerhet og sivilt-militært samarbeid.
http://www.regjeringen.no/Rpub/STM/20032004/039/PDFS/ST-M200320040039000DDDPDFS.pdf

JD (2005): Justis- og beredskapsdepartementet. Hovedprinsipper i beredskapsarbeidet:
http://www.regjeringen.no/nb/dep/jd/tema/samfunnssikkerhet-og-beredskap/hovedprinsipper-i-beredskapsarbeidet.html?id=447043

Johnson (2001): Functions in innovation system approaches. Conference paper, Nelson & Winter conference.

Kemp (2000): Technology and environmental policy – innovation effects of past policies and suggestions for improvement. In: OECD proceedings: Innovation and the Environment (p 35-61). OECD: Paris.

Klassekampen (2009): "For dårlig beredskap". 1. August 2009. Downloaded from atekst.no.

Klif (2012): Klifs beredskap ved hendelser.
http://www.klif.no/artikkel____31085.aspx

Kline & Rosenberg (1986): An overview of innovation.

Longva (2012): Norsk oljevern gjennom 40 år. Oslo: Kurér forlag.

Lovdata (1981): Lov om vern mot forurensninger og om avfall (Forurensingsloven).
http://www.lovdata.no/all/hl-19810313-006.html

Lovdata (1996): Petroleumsloven.
http://www.lovdata.no/all/nl-19961129-072.html

Lovdata (2012): Sentrale forskrifter til petroleumsloven.
http://www.lovdata.no/for/sf/sf-19961129-072.html

Lundvall (1992): National Systems of Innovation – toward a theory of Innovation and Interactive Learning. London: Pinter.

Malerba (2002): Sectoral systems of innovation and production. Research Policy, 31, 247-264.

Markard & Truffer (2008): Technological Innovation Systems and the Multi-Level Perspective: Towards an Integrated Framework. Research Policy, 37, 596-615.

Murmann & Frenken (2006): Toward a systematic framework for research on dominant designs, technological innovations, and industrial change. Research Policy, 35, 925-952.
http://econ.geo.uu.nl/frenken/murmannfrenken.pdf

Mytelka (2000). Local systems of innovation in a globalized world economy. Industry and Innovation 7 (1), 15–32.

NCA (2003): Presentation, Prestige Workshop.
http://ec.europa.eu/echo/civil_protection/civil/marin/reports_publications/prestige_workshop_catania_documents/session1/presentation_mr_bratfoss.pdf

NCA (2011a): Kystverket. Beredskapsanalyse knyttet til akutt forurensing fra skipstrafikk.
http://www.kystverket.no/PageFiles/6425/Beredskapsanalyse.pdf

NCA (2011b): Kystverket. Statlig beredskap.
http://www.kystverket.no/Beredskap/Forurensningsberedskap/Statlig-beredskap/

NCA (2012a): Beredskapsutstyr i Norge.
http://www.kystverket.no/Beredskap/Forurensningsberedskap/Ressurser/

NCA (2012b): Kurs- og øvelseskalender 2012.
http://www.kystverket.no/Global/Beredskap/HMS/%C3%A5rskalender%202012.20.02x.pdf

Negro (2007): Dynamics of technological innovation systems: The case of biomass energy. Phd-thesis, Utrecht University.
http://nws.chem.uu.nl/publica/Publicaties2007/NWS-E-2007-310.pdf

Negro, Suurs & Hekkert (2008): The bumpy road of Biomass Gasification in the Netherlands: Explaining the rise and fall of an emerging innovation system. Technological Forecasting and Social Change, 75, 57-77.

Nelson (1992): National Systems of Innovation: A Retrospective on a Study. Industrial and Corporate Change, 2, 347-374.

NMA (2011): Sjøfartsdirektoratet. Om direktoratet.
http://www.sjofartsdir.no/om-direktoratet/

NOFO (2011a): Our operations.
http://nofo.no/modules/module_123/proxy.asp?D=2&C=107&I=349

NOFO (2011b): Oljevern 2010.
http://www.nofo.no/Teknologiutvikling/Oljevern-2010/5E446F21-8794-454F-AA4B-8150E2D8E87E/1

NOFO (2012): Årsplan 2012.
http://www.nofo.no/%C3%98velser/%C3%85rsplan/722E0A09-6AE2-4302-8334-3EA62A30C45E/1

NOFO (n.d.): Presentation.
http://db4.nofo.no/stream_file.asp?iEntityId=938

Nordnorsk Beredskapssenter (2009): Rapport LoVe IUA. Sent by email.

OD (2011): Petroleumsressursene på norsk kontinentalsokkel 2011.
http://www.npd.no/Global/Norsk/3-Publikasjoner/Ressursrapporter/Ressursrapport-2011/Ressursrapporten%202011.pdf

OECD (2008): Policy roundtables: Monopsony and buyer power.
http://www.oecd.org/dataoecd/38/63/44445750.pdf

OFFB (2012): Om OFFB.
http://www.offb.no/default.asp

OG21 (2011): Technology Target Areas (TTA) 1. Energy efficient and environmentally sustainable technologies.
http://www.og21.org/prognett-og21/TTA1__Energieffektiv_og_miljovennlig_berekraftig_teknologi/1253963217201

OLF (2010): Operasjonsmanual for offshore service fartøyer, norsk sokkel.
http://www.nwea.info/postmann/dbase/bilder/OPERASJONSMANUAL%20FOR%20OFFSHORE%20SERVICE%20FART%D8YER%20NORSK%20SOKKEL%20%28revisjon%201-juli%202011%29.pdf

Porter (1980): Competitive strategy. London: Collier Macmillan Publishers.

Porter (1990): The competitive advantage of nations. London: Palgrave Macmillan.

Porter (2000): Location, competition, and economic development: Local clusters in a global economy. Economic Development Quarterly, 2000:15-34.
http://www.cob.sjsu.edu/osland_a/bus218/pdf/LocationCompetitionandEconomicDevelopmentLocalClustersinaGlobal%20Economy.pdf

PSA (2011): Petroleumstilsynet. Role and area of responsibility.
http://www.ptil.no/role-and-area-of-responsibility/category165.html

RCN (2011): Forskningsrådet. "Samfunnsoppdrag, mandat og visjon."
http://www.forskningsradet.no/no/Visjon_og_mandat/1138785796497

Rystad Energy (2011): Recoverable volumes of petroleum discoveries in the Barents Sea. Estimate developed for this thesis.

Saxenian (1991): The origins and dynamics of production networks in Silicon Valley." Research Policy, 20, 423-437.

Sintef (2010): Report no. 32: Joint industry program for oil spill contingency for Arctic and ice-covered waters. Summary Report. *http://www.sintef.no/project/JIP_ Oil_ In_ Ice/Dokumenter/publications/JIP-rep-no-32-Summary-report.pdf*

Sintef (2011): Helhetlig forvaltningsplan for Nordsjøen og Skagerak. Sektor: Petroleum. Tema: Oljevern. *http://www.klif.no/PageFiles/1635430/forvaltningsplan_ nordsjoen_ oljevern.pdf*

SNL (2011): Beredskap. http://snl.no/beredskap

Spilling and Rosenberg (2007): Det norske innovasjonssystemet – institusjonell struktur og innovasjonsaktivitet. In: Kunnskap, næringsutvikling og innovasjonspolitikk (p.69-96), Bergen: Fagbokforlaget.

SSB (2007): Sea freight transport survey. *http://www.ssb.no/godsund_ en/*

Suurs (2009): Motors of innovation: Towards a theory on the dynamics of technological innovation systems. PhD-thesis, Utrecht University. *http://igitur-archive.library.uu.nl/dissertations/2009-0318-201903/suurs.pdf*

Suurs & Hekkert (2009): Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands. Technological Forecasting and Social Change, 76, 1003-1020.

Swann (2009): The Economics of Innovation. Cheltenham: Edward Elgar Publishing.

Teece (1986): Profiting from technological innovation: Implications for integration, collaboration, licensing, and public policy. Research Policy, 15, 285-305.

The Telegraph (2011): Putin touts Arctic Northeast passage. *http://www.telegraph.co.uk/news/worldnews/europe/russia/8782861/Vladimir-Putin-touts-Arctic-Northeast-passage.html*

Thompson & Formby (1993): Economics of the firm, Theory and practice, 6th edition. London: Prentice-Hall International.

Tödtling (1998): Innovation systems in regions of Europe – A comparative perspective. Paper presented to the 38th congress of the European Regional Science Association, Vienna.

Tödtling & Trippl (2005): One size fits all? Towards a differentiated regional innovation policy approach. Research policy, 34, 1203-1219.

VG (2007): "Fadesen på Statfjord". 13. December 2007. Downloaded from atekst.no

Wacker (1998): A definition of theory: research guidelines for different theory-building research methods in operations management. Journal of Operations Management, 16, 361–385.

Yin R (2009): Case study research, Design and methods, 4th edition. California: SAGE.

Yr.no (2012): Historical data from Utsira and Vardø weather stations.

Appendix

1 Comparison of the largest oil spills in history

2 Technical sheet

3 Supplementary information about OSR companies

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5 NOFOs courses and exercises 2012

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7 OSR Patent applications, by Oslo patent office (1987-2010)

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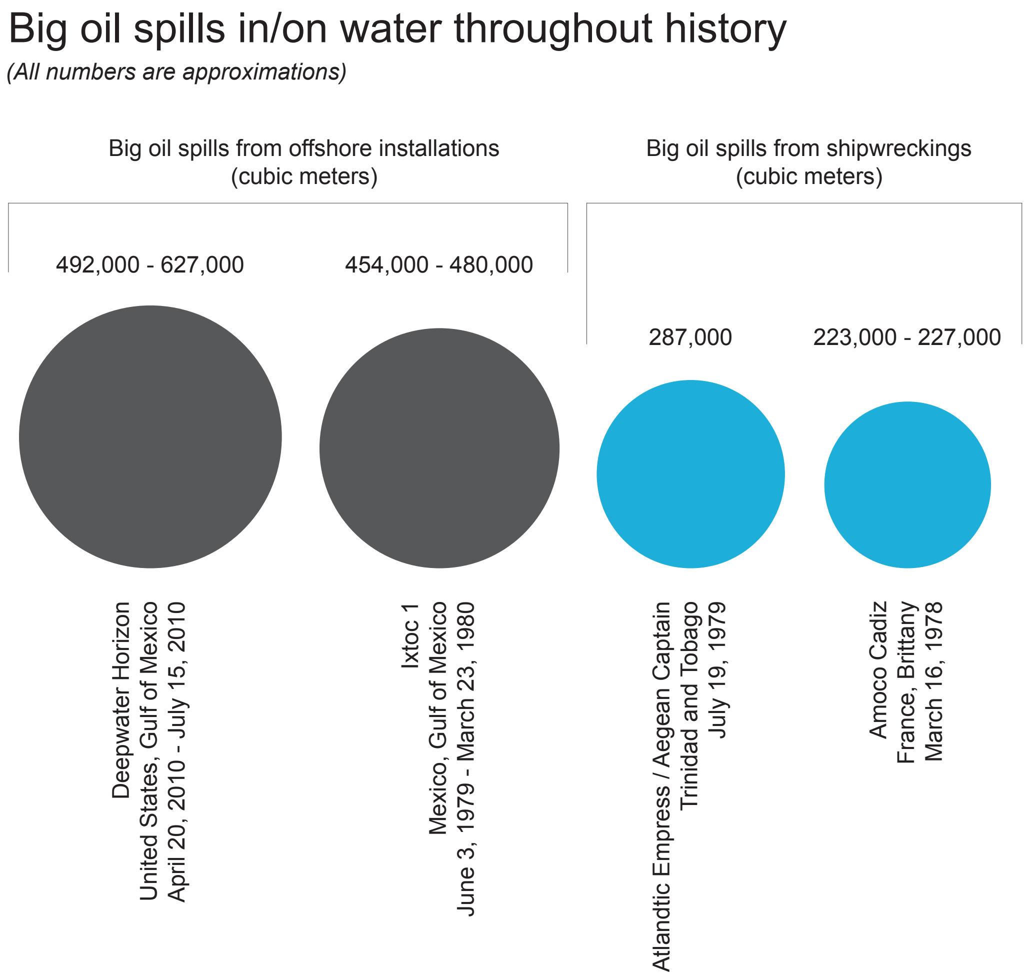
11 Map showing the 33 IUAs in Norway

12 Undiscovered gas resources in the High North

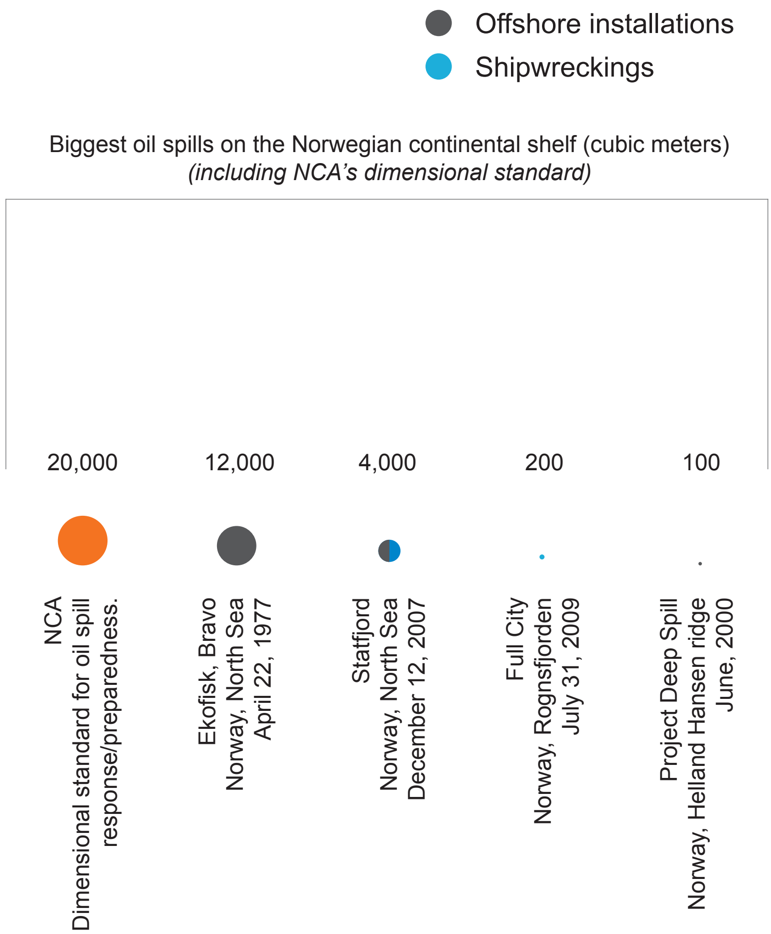
13 Business abroad and R&D spending for Norwegian OSR companies

1 Comparison of the largest oil spills in history



Sources: New York Times, Store Norske Leksikon, Longva (2012), Mother Nature Network.

Biggest oil spills on the Norwegian continental shelf (cubic meters)
(including NCA's dimensional standard)



2 Technical sheet

Method	Description of method	Equipment needed	Ideal distance from coast	Ideal weather & sea conditions
Mechanical recovery	Oil is removed from the sea using booms and skimmers.	Booms: Gather and keep the oil in a limited area. Skimmers: Mechanically retrieve the oil. Tanks: Vessels or similar that contain and move the retrieved oil to a designated area.	Can be used both close to and far off the coast. Shallow water can be a barrier for vessels skimmers.	Weather: Nice. Sea: Calm. Low currents.
Dispersion	Oil is dispersed into the water using chemicals and energy, or just energy.	Chemicals: Sprayed onto the oil to make the oil disperse quicker. Energy: Added to mix the oil with water and dispersants. Can be done without dispersants.	Can be used both close to and far off the coast. Chemicals can be hazardous to plants and corals close to the surface.	Weather: Nice. Sea: Big waves are ideal.
In-situ burning	Oil is burned on the surface of the sea.	Booms: Can be used to gather the oil in order to get a more concentrated burning.	The further from coast the better. Should not be used close to the coast.	Weather: Nice. Sea: Calm. Low currents.
Beach clean up	Oil is removed from land	Absorbents: Bark or similar used to absorb oil and create a dry mass. Vacuums: Used to vacuum oil into a tank.	Used on the coast or other dry surfaces.	Weather: Nice. Sea: Calm. Small waves.
Remote sensing	Detect, sense and control oil spills when direct vision is challenging.	Radars, infrared cameras, night vision and other technological equipment for enhanced vision.	Can be used at all distances from the coast.	Used when the weather and sea conditions are not ideal.

Sources: Sintef, information from several Norwegian OSR companies by research and interviews.

Window of opportunity	Level of use in Norway today	Negative effects and factors	Norwegian actors	Comments
The more spreading and dispersion of the oil, the less effective is mechanical recovery. Can be used until the oil have totally dispersed.	Very high	Labour intensive. Expensive equipment. Much equipment must already be installed on vessels, or be stored close to the accident site. Booms are sensitive to currents and waves.	Booms: Norlense, NOFI, Markleen, Coastsaver, Expandi. Skimmers and pumps: Skimmer Tech, H. Henriksen Mek. Verksted, Frank Mohn	
Chemicals are most effective when the oil is concentrated. Natural dispersion happens all the time regardless of time.	None. Work in progress to implement.	Dispersed oil and chemicals can damage life close to the surface. The oil is not removed. Must apply right amount of chemicals and enough energy. Perishability is rarely more than 10 years.	Dispersion systems: Jason Engineering, Markleen. Dispersant producers: Several producers (Dispersants are also used ofr other purposes)	Not used in Norway until recently. The main oil spill counter-measure in United Kingdom.
Must be ignited before the oil has weathered too much.	Close to zero	Smoke pollution. Visually not attractive. Only works in a relatively short window of opportunity.	No specialized companies.	Not allowed in Norway. Much more common in America.
As fast as possible to avoid harm to wildlife and environment.	Used when necessary	Very costly.	Kaliber Industridesign, Vacuumkjempen Nord, Abtek AS, and more.	Last method of counter-measure. Damage is already done.
The thicker the oil sheet, the easier to spot.	Used to a large extent both i oil spill response and other marine activities.	Not an oil spill countermeasure. A support technolgy for the actual countermeasures.	Miros AS, Aptomar.	

3 Supplementary information about OSR companies

Aanderaa Data Instrument (Aadi) AS

- Business: Operations
- Location: Bergen
- Established: 1975

Aadi designs, manufactures and sells sensors, instruments and systems for measuring and monitoring in demanding environments. Main market areas are Marine Transportation, Oil and Gas, Aquaculture, Environmental Research, Road and Traffic and Construction.

AllMaritim AS

- Business: Sales / Marketing
- Location: Bergen
- Established: 1988

AllMaritim is a supplier of equipment and services to the international OSR industry. It has two main manufacturers, NOFI AS and Noren AS. Products sold by AllMaritim are presently in active use in more than 30 countries.

Aptomar AS

- Business: Production / Sales / Marketing
- Location: Trondheim
- Established: 2005

Aptomar develops and delivers technical solutions for environmental monitoring, including solutions adapted for oil spill detection and monitoring.Statoil Venture, Proventure Seed, Investinor and NTNU TTO are some of the shareholders of Aptomar.

Arctic Protection

- Business: Operations
- Location: Honningsvåg
- Established: 2005

Arctic Protection is a supplier of integrated concepts for all maritime operations, including operative OSR solutions. Arctic Protection also delivers courses in OSR training and maritime training.

Expandi AS

- Business: Production
- Location: Skien
- Established: 1970

Expandi designs and develops self-inflatable booms. It also supplies a wide range of other oil booms and oil skimmers in addition to consulting services. Expandi is originally a Swedish company, but its Norwegian division is operated from Skien.

Frank Mohn AS (Framo)

- Business: Production
- Location: Bergen
- Established: 1938

Frank Mohn AS manufactures submerged pumping system for shipping and offshore industry. Frank Mohn AS also has an oil spill recovery department that produces oil skimmers, pumps and equipment for emergency offloading.

H. Henriksen Mekaniske Verksted AS

- Business: Production
- Location: Tønsberg
- Established: 1856

H. Henriksen Mekaniske Verksted produces oil skimmers, including the Foxtail vertical adhesion band oil skimmer. They also produce other oil spill related products as emergency offloading systems and absorbent blaster.

Markleen AS

- Business: Production
- Location: Bærum
- Established: 1993

Markleen offers a wide range of OSR equipment including booms, skimmer, pumps, sorbents and dispersant spray equipment. It is an international company represented in 5 continents.

Miros AS

- Business: Production
- Location: Bærum
- Established: 1984

Miros delivers wave and water monitoring including the Miros Oil Spill Detection System that has become a standard for Oil Response Vessels on Norwegian oil fields. It also operates in the fields of meteorology and oceanography, and offers products for wave and tide monitoring.

Maritim Miljø Beredskap (MMB) AS

- Business: Operations
- Location: Bergen
- Established: 1999

MMB is a supplier of operative OSR solutions. MMBs services include rental of OSR equipment and personnel, management of OSR operations, OSR courses and training and consulting services.

NOFI AS

- Business: Production
- Location: Tromsø
- Established: 1978

NOFI develops and produces a wide range of oil booms, including the Current Buster that is designed to handle much stronger currents than conventional oil booms. Other business areas are fishery and aquaculture. All sales are done through AllMaritim AS.

Norén AS

- Business: Production
- Location: Bergen
- Established: 2002

Norén specializes in design and production of oil spill recovery equipment, including booms, pumps and skimmers. All sales are done through AllMaritim AS.

Norlense AS

- Business: Production
- Location: Fiskebøl (Troms)
- Established: 1975

Norlense is one of the world's leading companies for development and manufacture of Oil Spill Emergency Equipment and specializes in oil recovery boom systems. Other main areas of business are inflatable tents and OSR courses and training.

Norwegian Petro Services (NPS) AS

- Business: Consulting
- Location: Harstad
- Established: 2006

NPS provides advice and services for petroleum-related activities with emphasis on operational OSR planning. It was acquired by DNV in 2012 as a part of DNVs increasing focus on OSR.

Seaworks AS

- Business: Operations
- Location: Harstad
- Established: 1995

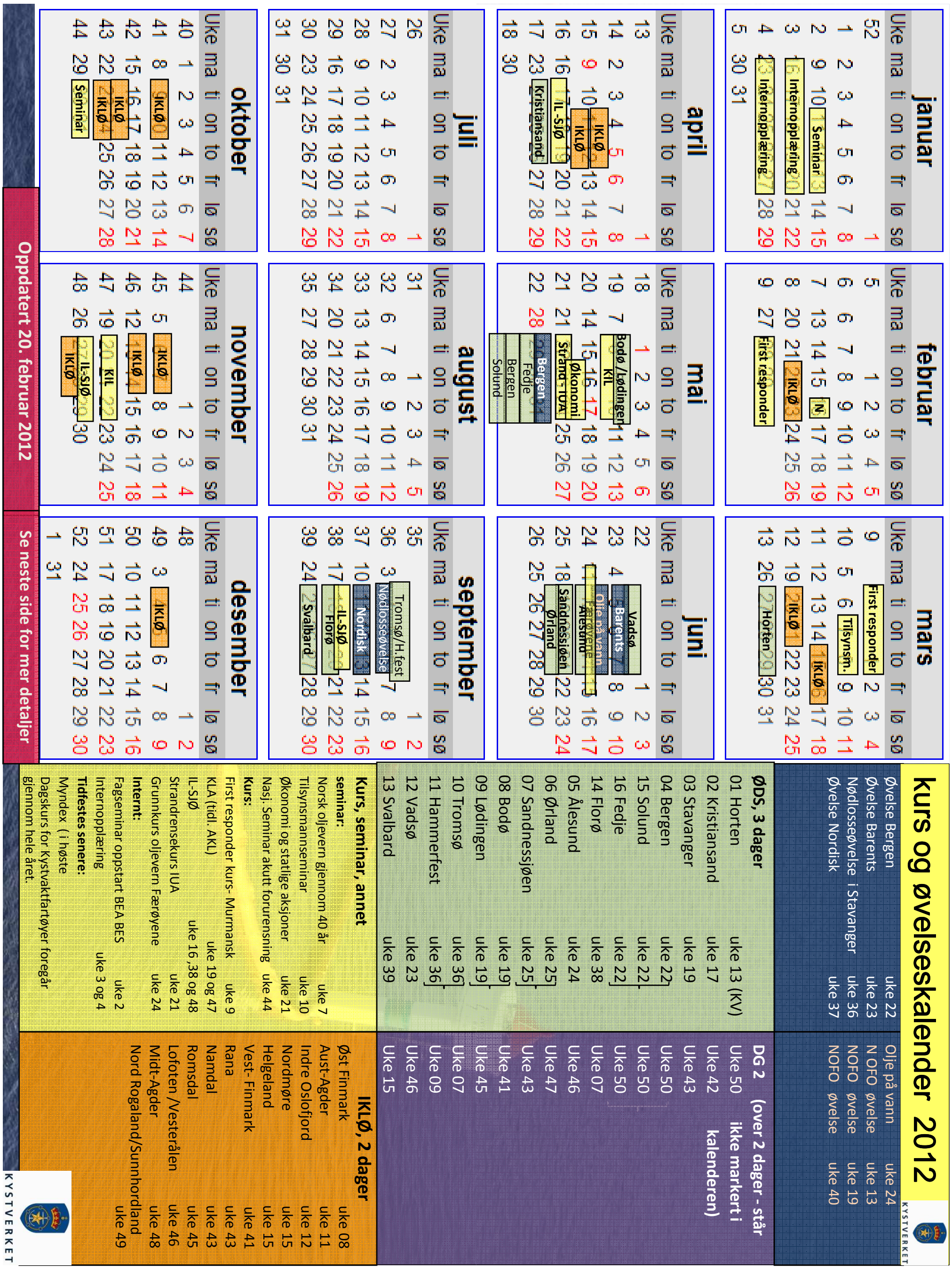
Seaworks specializes of marine services, including transport broking services. Only a small part (1-2%) of Seaworks' operations is connected to OSR, with emphasis on beach clean-up.

Skimmer Technology

- Business: Production
- Location: Søgne (Vest-Agder)
- Established: 1965

Skimmer Technology designs and develops the OP Oil Skimmer – A multitask vessel design for efficient oil skimming. The company was founded in 1965, and started OSR related product development in 1993.

Sources: Web sites of researched companies.



Source: *kystverket.no*

Årsplan NOFO 2012
(inkludert Kystverkets øvelser)

Aktivitet	Januar	Februar	Mars	April	Mai	Juni	Juli	August	September	Oktober	November	Desember	Mrk
NOFO kurs	3	6,7	9,12	16	20,21,22			33,34	36,39	42	44,45,47	49	
Fjernmåling					18				37				
Dispergering					18				37				
IGSA			11,12								45		
IL Hav/sjø				16					38		48		
Kystnær oljevern-Beredskaps kurs			11		18								
2 Fullskala øvelser			13		19					40			
IUA samling			11										
OPV						24							
Samling Beredskaps-grupper		9									46		
NBSK kurs (NOFO)	5	7		16,17	18,19				36,38				
ELS kurs IUA													
Samling spes team									35				
NOFO (fag)seminar	2												
IKLØ		8,10	11,12	16						42,43	45,46,47	49	
Depot øvelse			13	17	19,22	23,24,25			36,39				
KyV storøvelse					22	23			36,38				
Seminar						24							
Kystnær fartøy øvelse					20,21	24							

All aktivitet er satt opp med uke nummer.

Norsk Oljevernforening For Operatørselskap
Vassbotnen 1, 4313 Sandnes
Tlf: 51 56 30 00 / www.nofo.no

Source: nofo.no

6 Supplementary info, NOFOs Oljevern 2010 projects

Company	Project name
Åkreham Trålbøteri AS	"Oil Shawer" - New oil recovery concept
Frank Mohn Flatøy AS with partners	"HISORS" - High Sea Oil Recovery System"
Vikoma International Ltd	"HISCOR" - High Speed Continuous Oil Recovery System
MDGroup AS	Marine Oil Spill (MOS) Sweeper - New oil recovery concept
Salford Electronic Consultants Ltd	Boom Management System (1)
Aanderaa Data Instruments AS	Boom Management System (2)
ORC AB	"BV-Spray" - Dispersant application system
Aptomar AS	Dispersant dosing
ISPAS AS	Development of the next generation oil detection radar (FMCW)
Aptomar AS	"TCMS" - Bridge console for real-time remote sensing data
Maritime Robotics AS	"Ocean Eye" - compact aerostat system for oil spill remote sensing
Salford Electronic Consultants Ltd	Digital downlink between aircraft and vessel
Aranica AS	Unmanned aerial system (UAS) for coastal remote sensing
CodarNor AS	SeaSonde - Rapid deployable HF-radar for real-time monitoring of surface currents
H. Henriksen AS	"Foxbarge" - a work platform transported and stored as a 40' container
Vacumkjempen Nord-Norge AS	High capacity granulate application (and recovery) of granulate on shorelines
H. Henriksen AS	"Foxtail MINI" - Portable mop skimmer
Mercur Maritime AS	"Messor" - beach cleaning system
Team Innovation Trondheim AS	"MAV Oil Spill Fighter" - Archimedes screw vehicle
Kaliber Industridesign AS	"MOSE" - Equipment to improve the efficiency of shoreline clean-up operations

Source: nofo.no

7 OSR Patent applications, by Oslo patent office (1987-2010)

Appl. No.	Name	Granted	Tech. Type
19872873	Blanding for dispergering av oljesøl på vann	7/10/87	Dispersion
19911618	Anordning for oppsamling av oljesøl	4/24/91	Mechanical
19914129	Oljeopptaker for oljesøl på en vannflate	10/21/91	Mechanical
19920168	Absorpsjonsmiddel, fremgangsmåte for fremstilling av absorpsjonsmiddel samt anvendelse av dette	1/13/92	On-land
19925053	Hydrosyklon for rensing av oljesøl	12/30/92	Mechanical
19932594	Innretning for lagring av olje under vann	7/16/93	Mechanical
19934018	Fremgangsmåte og innretning for gjenvinning av oljesøl	11/5/93	Mechanical
19940976	Oljeoppsamlingsutstyr	3/18/94	Mechanical
19980572	Forbedret kjemisk dispergeringsmiddel for oljesøl	2/10/98	Dispersion
19981838	Oljeskimmer	4/24/98	Mechanical
19983551	Oljeoppsamler og fremgangsmåte for oppsamling av olje	8/3/98	Mechanical
19991949	Anvendelse av et additiv som emulgator, dispergeringsmiddel og som forbrenningsforbedrende middel til tungoljer	4/23/99	Dispersion
19993850	Dispergeringsmiddelformulering for rensing av oljesøl	5/18/05	Dispersion
20003952	Anordning og system for oppsamling av oljesøl og liknende	8/4/00	Mechanical
20022814	Kjemisk dispergeringsmiddel for oljesøl	6/13/02	Dispersion
20025014	Oljelense samt anvendelse av denne	10/18/02	Mechanical
20033849	Vandige dispersjoner av tungoljerester	8/29/03	Dispersion
20040109	Tofase-dispergeringsblandinger for oljeprodukter	1/9/04	Dispersion
20091090	Fremgangsmåte og system for måling/detektering av kjemikaliesøl	3/12/09	Sensing
20100743	Metode for utskillelse av olje fra vann ved hjelp av needsenkbar oljeutskiller	5/21/10	Mechanical

Source: Oslo Patentkontor

8 Survey handed to OSR companies

Spørreskjema i forbindelse med masteroppgave ved NTNU våren 2012
Tittel på masteroppgave: Industrielle muligheter innenfor oljevernberedskap i Norge
MSc-studenter: Kristian Bergaplass og Christian Eriksen

Informasjon angående spørreskjema:
Side 1: Økonomiske spørsmål (Knyttes opp mot bedriften)
Side 2: Spørsmål angående oljevernberedskapsmarkedet i Norge (Vil IKKE knyttes opp mot bedriften)

Bedrift:

Person:

I hvilket felt har deres bedrift sin hovedgeskjeft? (Hvis flere, velg den viktigste)		
Operasjoner	☐	Kommentarer:
Produksjon	☐	
Markedsføring/Salg	☐	
Konsulentvirksomhet/rågiving	☐	
Annet	☐	

Hvor mange prosent av bedriftens virksomhet er i direkte tilknyttet oljevern-/kystnær beredskap?		
0-20%	☐	Kommentarer:
20-40%	☐	
40-60%	☐	
60-80%	☐	
80-100%	☐	

Hvor mange prosent av bedriftens virksomhet er i utlandet?		
0-20%	☐	Kommentarer:
20-40%	☐	
40-60%	☐	
60-80%	☐	
80-100%	☐	

Hvordan ser dere på utviklingen for deres bedrift ift markedene i Norge vs. utlandet?		
Utlandet vil bli viktigere	☐	Kommentarer:
Viktigheten av markedene i Norge og utlandet vil bli omtrent som i dag	☐	
Norge vil bli viktigere	☐	

Hvilke kunder i Norge, utenom NOFO og Kystverket, har dere i dag?

Svar:

Hvor stor andel av deres bedrifts omsetning går til R&D/Innovasjon?		
0-5%	☐	Kommentarer:
5-10%	☐	
10-15%	☐	
15-20%	☐	
Over 20%	☐	

[INFORMASJON FRA DENNE SIDEN AV SPØRRESKJEMAET VIL IKKE BLI KNYTTET DIREKTE TIL BEDRIFT I MASTEROPPGAVEN]

I hvor stor grad er du enig i at følgende ord karakteriserer det norske beredskapsmarkedet?

	Helt uenig	Litt uenig	Verken-eller	Litt enig	Helt enig
Åpent					
Oversiktlig					
Innovativt					
Rivaliserende					
Skjermet					
Enkelt å etablere seg i					
Preget av kjøpermakt					
Dynamisk					
Dysfunksjonelt					
Internasjonalisert					
Sentraldirigert					
Profitabelt					
Markedssvikt					

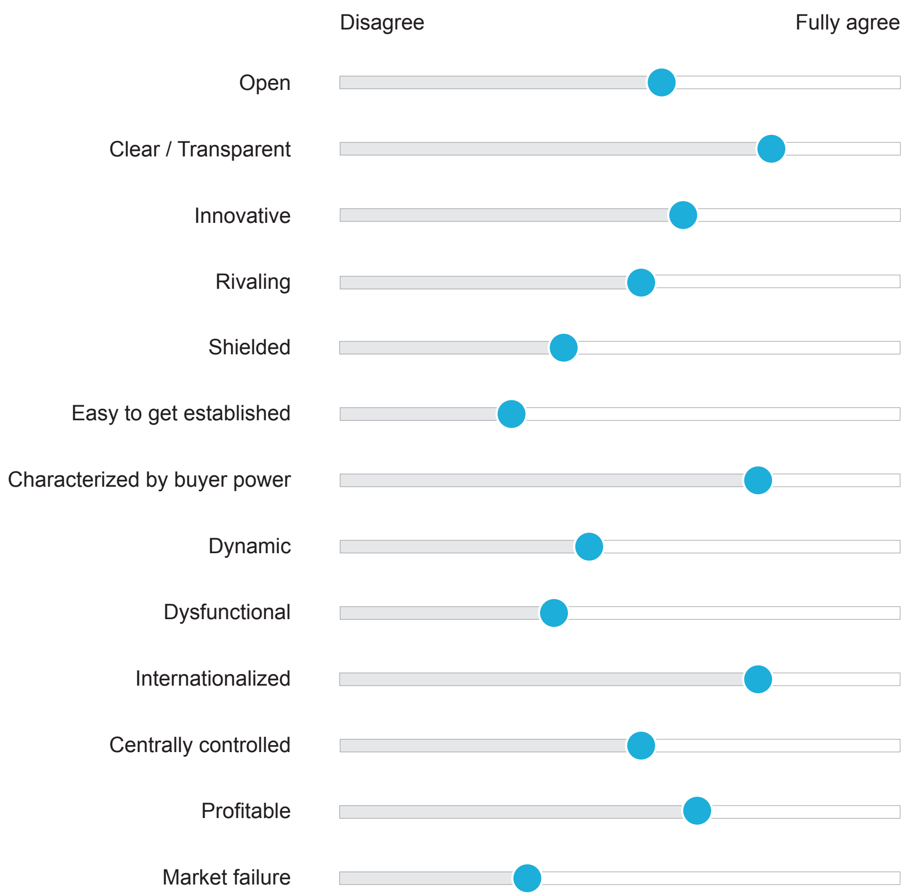
I hvor stor grad er du enig i følgende påstander?

	Helt uenig	Litt uenig	Verken-eller	Litt enig	Helt enig
Oljevernberedskapen i Norge i dag er tilstrekkelig					
Organiseringen av ansvar er riktig og oversiktlig					
Ansvarlige tilsyn har tilstrekkelig kompetanse					
Ansvarlige tilsyn gjør en god jobb					
Norske bedrifter er verdensledende					
Norske bedrifter vil forbli verdensledende (på kort sikt)					
Norske bedrifter har høyere grad av kunnskapsutvikling enn utenlandske bedrifter					
Norske bedrifter i beredskapsmarkedet har i hovedsak beredskap som bigeskjeft					
Organiseringen av beredskap gjennom NOFO er positivt for oljeselskaper					
Organiseringen av beredskap gjennom NOFO er positivt for beredskapsmarkedet					
Organiseringen av beredskap gjennom NOFO er positivt for beredskapen i Norge					
Kystverket og NOFO bidrar sterkt til innovasjon					
Kystverket klarer å skille godt mellom rollene som innkjøper, forbruker og tjenesteprodusent					
Beredskap bør i større grad konkurranseutsettes i Norge					

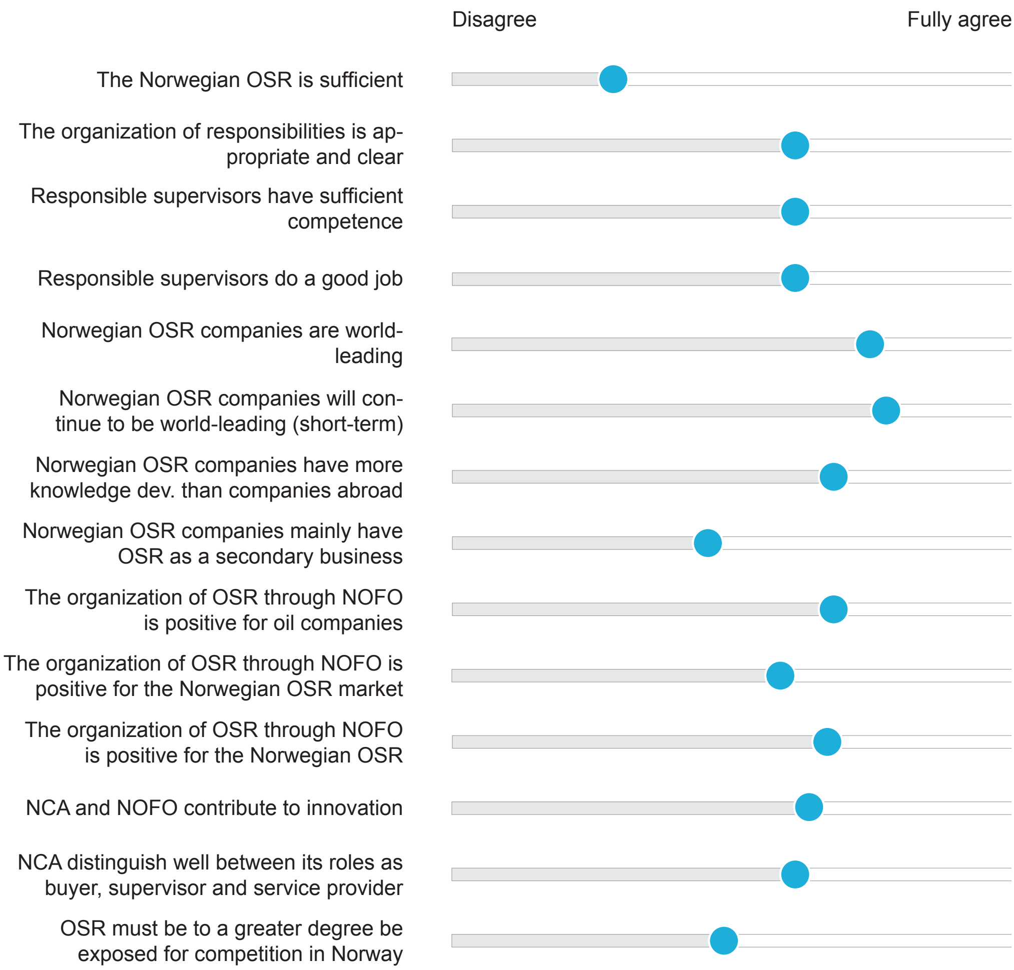
9 Characteristics of the Norwegian OSR market

The survey in Appendix 8 was answered by 10 Norwegian OSR companies in order to provide a brief insight into how these companies consider the structure and functioning of the Norwegian OSR market. Each question had 5 options (Fully disagree, somewhat disagree, neutral, somewhat agree, fully agree). The bars below are based on the average of these answers.

Question: To what degree do you agree that the following words characterize the Norwegian OSR market?



Question: To what degree do you agree with the following statements?



The following subchapters are parts of an analysis based on Porter's Five Forces framework. Each of the five forces is examined separately, and the total industry picture will be summarized in the end. This analysis is conducted to determine how strong the forces in the market are compared to each other, which may aid in the later discussion of this market.

1 Threat of new entrants

How likely is it that there will be new entrants to the industry, which may threaten the existence of the incumbent firms? The likelihood of new entrants is affected by such factors as barriers to entry, possible incumbent retaliation, and experience effects.

There are five sources of barriers to entry identified in Porter (1980) that apply to this industry:

1. Economies of scale: As the OSR industry is not an industry dependent on volume, economies of scale do not play a major role in creating barriers to entry.
2. Capital requirements: The amount of capital required to enter the industry depends highly on the sophistication of the technology. While there may be a strong capital need to develop sensors, it is not as strong for the development of oil booms.
3. Switching costs: Many response technologies work as integrated systems, and can be operated without other specialized equipment. This is the case for oil booms and skimmers. In general, it seems to be not very high switching costs involved.
4. Cost advantages independent of scale: There do not seem to be evident cost advantages independent of scale in the industry.
5. Government policy: There is a clear barrier to entry into the production of services for oil spill preparedness and response. This is due to the NCA producing services of its own. Another barrier is raised (unintended) by government policy through the governmental specifications for equipment approved for use. By specifying too closely which attributes equipment must have, the government de facto decides which brand of equipment companies shall use. «Becoming a part of the specification» has been mentioned by several interviewees as a strategy for increasing sales.

Another issue is the entry-deterring price. It varies considerably depending on which part of the OSR industry the firm enters. An example is Coastsaver, an oil boom producer, which has made no major investments in assets as production is outsourced. The picture would be another if the firm goes into operational services, demanding major investments in equipment.

The airline industry has seen incumbent retaliation with every new entrant. The Norwegian airline Color Air was in the end driven out of business after SAS dropped their prices considerably. In OSR, this kind of price maneuvering may not be as likely. As prices are determined to a large extent by bargaining power, it may not even be possible.

Experience effects, on the other hand, are likely to increase the barriers to entry. Learning effects from years of development and testing in cooperation with the NCA and NOFO is surely to be a major advantage to the incumbent firms. Economies of scale may also play a role here.

A related issue is government involvement. Tight relations between incumbent firms and the NCA as both government purchaser, regulator and operationally responsible will deter new entrants. The government does, on the other hand, actively support new firm foundation through Innovation Norway.

In summary, new entrants may not be deterred by entry cost or incumbent retaliation. They may also be able to secure funding for new development from the government. But close relations between incumbent firms and the buyers are a problem for new entrants. Experience effects have a major effect. On a five-point scale, the threat of new entrants is estimated to be a medium-weak force (2-3).

2 Bargaining power of suppliers

In general it seems that the bargaining power of suppliers is not a strong force in the market. Suppliers to the producers of OSR equipment in general supply important, but quite basic input, e.g., input that can be bought from many companies. There is not a strong concentration of suppliers that can wield market power, and there is no chance of forward integration by the supplier. The industry is probably not a major customer of the suppliers either. Switching costs for the industry may vary, but is evaluated not to play a major role.

The labor force is also counted as a supplier. In Norway labor in general has strong rights, and consequently has strong bargaining power against their employers.

In general, the bargaining power of suppliers is not a strong force in this industry. On a five-point scale, the bargaining power of suppliers is estimated to be weak force (1).

3 Bargaining power of buyers

As previously mentioned, there are two major buyers in the Norwegian market: the NCA and NOFO. They maintain stockpiles along the coast for the government and the private sector, respectively—a division of responsibility that reflects the strong concentration on the buyer side. This organization is an origin of strong bargaining power of buyers. Also, if the buyer represents a high proportion of the firm's sales, then the bargaining power of the buyer increases. This may be the case in the Norwegian market.

A second and related issue is how much of the buyers' total purchases are supplied by the Norwegian industry. As both the NCA and NOFO buy mainly from Norwegian firms, the importance of the Norwegian industry is strong for the buyers. The buyers will then emphasize cost control, attempting to drive down prices across the industry. In addition, both the NCA and NOFO are non-profit organizations, dependent on financing from its members or the government. This is a clear incentive for lowering prices. Price sensitivity will be an issue for the industry.

A third factor increasing buyer power is access to information. The NCA is the government purchaser, it holds information on many aspects of the market. It is reasonable to assume that NOFO also knows well what is happening in the market, due to their size and their close cooperation with the NCA.

A factor that is not mentioned by Porter (1980), but is valid in this situation, is the «lumpiness» of orders. Both the NCA and NOFO purchase new equipment in large and infrequent orders. This creates uncertainty in the market, and reduces the planning possibilities of sellers. It increases the bargaining power of buyers. Also, there are few switching costs, further increasing their bargaining power.

A factor that in principle should decrease buyer power is some differentiation in the industry. An example is that there are several different types of oil booms, supplied by different producers. Still, these are assessed to be too few to have a net impact on buyer power. In general, the different niches of the market are filled by a single company.

One may also present the objection that the importance of quality is paramount to price, and as such the sellers would increase their power relative to the buyer. This is the case. Another factor reducing buyer power is that backward integration is unfeasible for any of the buyers. This is not an available means of coercion.

In summary, there are some very strong factors indicating high bargaining power of buyers. There are also factors working the other way—industry differentiation, importance of quality, no backward integration—but these are few. On a five-point scale, buyer power is evaluated as a very strong force (5).

4 Threat of substitutes

A substitute product is in essence a product that can perform the same function as the product of the industry. As the industry is broadly defined in this thesis, there are no clear substitutes for the OSR products. A quasi-substitute would be investing more in preventative measures (barrier 0). Internally in the industry there are some substitutes, e.g. in oil booms. As such, the threat of substitutes is evaluated as a weak force (1).

5 Industry rivalry

Different types of OSR equipment are normally complementary to each other, rather than substitutes. Therefore, the market for such equipment has room for many smaller actors, rather than converging towards oligopoly. However, there are several direct competitors also. Norlense and Nofi both produce oil booms. Arctic Protection and Norwegian Petro Services both consult on operative contingency planning. Miros and Aptomar both deliver specialized instrumentation services. The existence of few direct competitors tends to decrease industry rivalry.

A related factor is diversity. As product diversity increases, rivalry decreases. In the Norwegian industry, product diversity is fairly high. This factor then has a decreasing effect on industry rivalry.

A factor that would increase rivalry is low growth, as one firm's increase in sales would displace another's. In the Norwegian industry there has been some growth in recent years, especially in the recovery from the financial downturn of 2008. There has also been a marked increase in government spending in the form of tied grants since 2006, but this is expected to level out in the coming years. In any case, recent growth may contribute to decrease rivalry if it is sustained.

Another factor of interest for the force of industry rivalry is exit barriers. Certain reasons may induce firms to stay in the industry despite low profits, thereby increasing rivalry. One such reason may be sunk costs that are unrecoverable at an exit. Asset specialization seems to be fairly moderate in the Norwegian market. Firms in operational services may be the firms most prone to such costs. As many firms produce «related» products, and may therefore be able to handle product line changes relatively easily, asset specialization seems in general not to be a major issue. Low exit barriers is a factor that contributes to decrease rivalry.

What may be more pertinent is the specific product market's importance in the firm's strategy. Examples are Norlense and NOFI—oil boom producers with several other products in their portfolio—which probably would go to great lengths to stay in the Norwegian oil boom market even under serious pressure from competitors. This may be due to the importance of the home market, being able to use the Norwegian market as a reference when doing business internationally. This factor contributes to increasing rivalry.

As has already been pointed out, there is a lack of switching costs in this industry. This factor contributes to increasing rivalry, as buyers rather easily may switch suppliers.

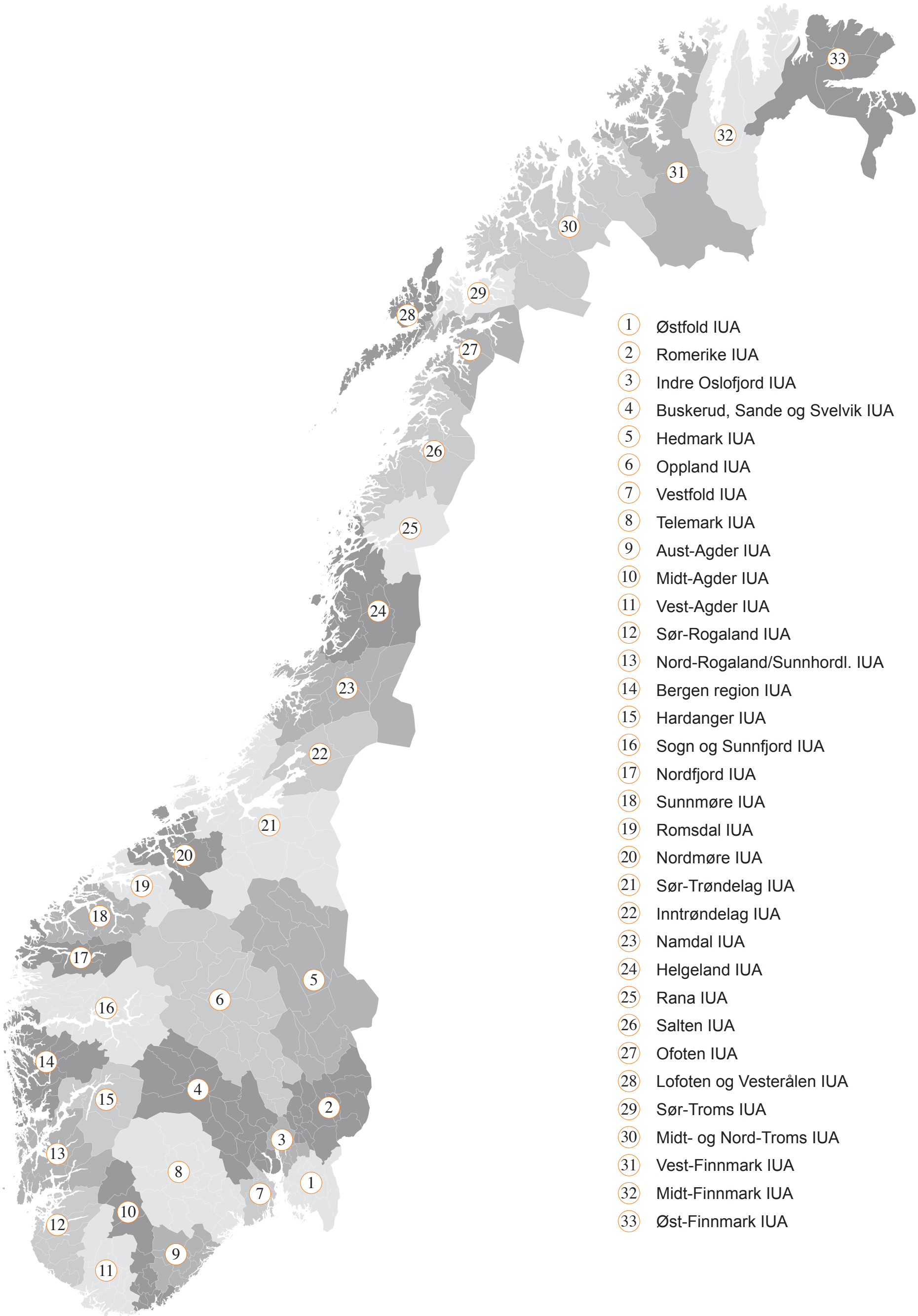
A last factor that must be mentioned is the buyers' interest in sustaining the market. It is in both major buyers' self-interest to ensure that the Norwegian industry is healthy and develops, to be able to serve the buyers well in the future. None of the actors expect that they would be better off if the Norwegian firms went bankrupt or lost their market share to major international companies. Therefore, the buyers have an interest in keeping industry rivalry in check.

In summary, there are strong factors that both increase and mitigate rivalry in the industry. The force of industry rivalry is evaluated to be a medium-strong force (3).

Summary of the five forces

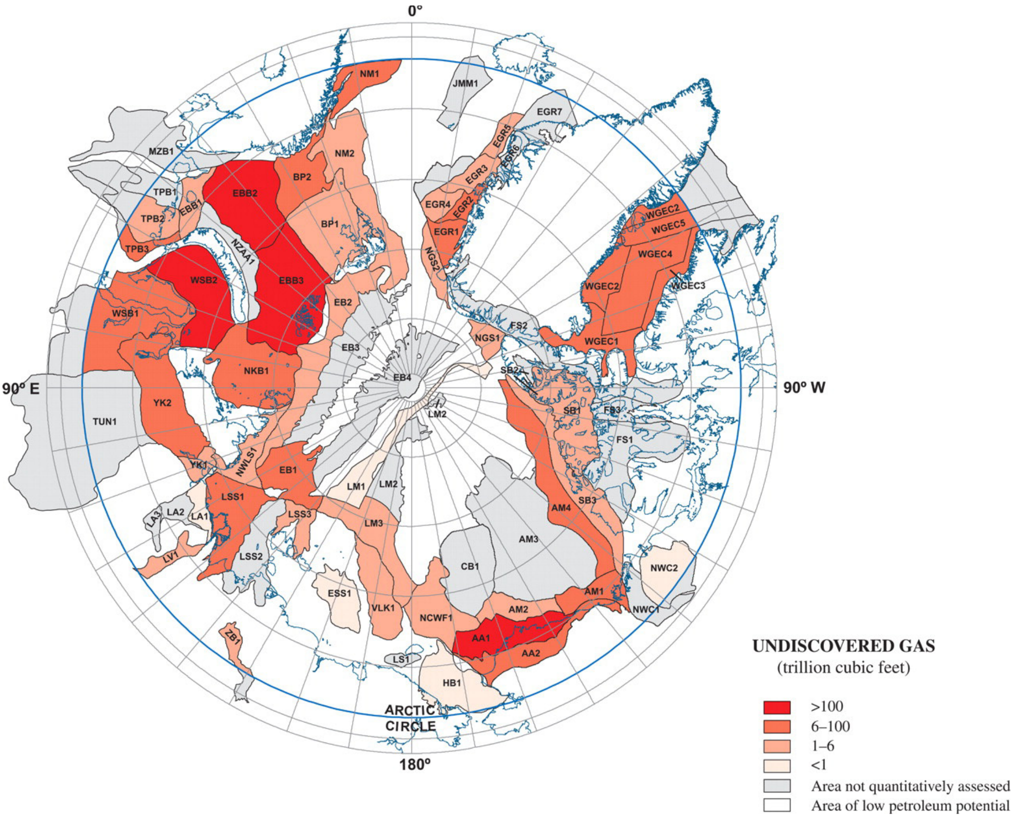
This analysis of the five forces in the industry reveals that suppliers and substitutes do not influence the market very much, new entrants and industry rivalry does influence the market to some extent, while the major force in the market is the bargaining power of buyers.

11 Map showing the 33 IUAs in Norway



1. Østfold IUA
2. Romerike IUA
3. Indre Oslofjord IUA
4. Buskerud, Sande og Svelvik IUA
5. Hedmark IUA
6. Oppland IUA
7. Vestfold IUA
8. Telemark IUA
9. Aust-Agder IUA
10. Midt-Agder IUA
11. Vest-Agder IUA
12. Sør-Rogaland IUA
13. Nord-Rogaland/Sunnhordl. IUA
14. Bergen region IUA
15. Hardanger IUA
16. Sogn og Sunnfjord IUA
17. Nordfjord IUA
18. Sunnmøre IUA
19. Romsdal IUA
20. Nordmøre IUA
21. Sør-Trøndelag IUA
22. Inntrøndelag IUA
23. Namdal IUA
24. Helgeland IUA
25. Rana IUA
26. Salten IUA
27. Ofoten IUA
28. Lofoten og Vesterålen IUA
29. Sør-Troms IUA
30. Midt- og Nord-Troms IUA
31. Vest-Finnmark IUA
32. Midt-Finnmark IUA
33. Øst-Finnmark IUA

12 Undiscovered gas resources in the High North



Source: Gautier et al. 2009

13 Business abroad and R&D spending for Norwegian OSR companies

Company	Main business	Business abroad	Share of revenue spent on R&D
Aadi	Production	0-20%	5-10%
AllMaritim AS	Marketing/Sales	60-80%	10-15%
Aptomar	Production	40-60%	15-20%
Arctic Protection	Operations	0-20%	10-15%
Expandi	Production	60-80%	10-15%
Frank Mohn AS	Production	60-80%	0-5%
H. Henriksen	Production	0-20%	10-15%
Markleen	Production		
Miros AS	Production	40-60%	10-15%
MMB	Operations	40-60%	10-15%
NOFI	Production		
Norén	Production		
NorLense	Production	60-80%	0-5%
NPS	Consulting	0-20%	
Seaworks	Operations		
Skimmer Tech	Production	80-100%	10-15%