MASTER

Strategic niche management for offshore industry
exploratory research on the introduction of innovative process hardware for marginal gas fields in the North Sea

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Preface

This paper reports on the research conducted for Körndorffer Contractors International bv (KCI) about factors that influence the diffusion of its products. This research is conducted as final requirement in order to earn a master’s degree at faculty Technology and Policy of the Technical University of Eindhoven (TU/e).

This thesis gives KCI insight of the theories that can be used to identify and manage factors that influence the diffusion rate of new technology into the existing market that is dominated by the established technology. In order to weaken the dominance of the established technology, the designers of new technologies should be creative but learn from societal factors starting from the niche development. The Strategic Niche Management (SNM) approach is used as theory to analyze the quality of key processes during the niche development phase.

During the research I ran into the shortcomings of SNM. I realized that I needed to investigate factors related to a wider concept. Further research resulted into supporting SNM with Multi Level Perspective (MLP) and Technology Commercializing approach. My findings are based on surveys, interviews and presentations organized by me.

I want to thank Prof. M. de Vries and Dr. R. Raven for their patience in reviewing my draft reports and giving me professional advice. Also I want to thank them for being present at my presentation held on May 20, 2007 at KCI.

I also want to thank the following persons for answering all questions (survey and interviews) related to the KCI projects. They have also been presented at my presentations held on March the 1st, 2007 and May 20, 2007 at KCI. These persons that supported me with technical and historical information are:

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- Mr. D. Körndorffer (Technical manager of KCI)
- Mr. E. van Drunen (Manager projects of KCI)
- Mr. W. Caris (Process engineer of KCI)
- Mr. M. Lemans (Piping engineer of KCI)
- Mr. E. Berkman (Structural engineer of KCI)

Also I want to thank the support the faculty Offshore Technology of Technical University of Delft that I have received from the following persons:

- Mr. G. Lagers (Offshore technology faculty) TUD
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Last but not least I want to thank my beautiful wife J. Vrutaal-Pantoflet who supported me although I have spent many hours at night during weekdays and in the weekends on this thesis. We got married on 07-07-2007 around that time I was very busy with the wedding and this thesis. Perseverance and self-motivation are the two magic words that have helped me finish this course at TU/e and this thesis.

R. Pantoflet
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Introduction

The oil and gas companies extract buried combustible geologic deposits of organic material ( decayed plants and animals) which is called fossil fuel. Fossil fuels are crude oil, natural gas and coal. Crude oil is a liquid found in porous rock formations in the earth’s crust which consists of a mixture of hydrocarbons of various lengths. The length range is C_{5}H_{12} (Pentane) to C_{18}H_{38} (Octadecane). Shorter chains are called natural gas while longer chains are more solid (grease) and the longest chains are coal. Crude oil is well-known as fuel oil and gasoline for the transportation systems. However crude oil is also the raw material for many chemical products as for example plastics and pesticides. Since the mid-1950’s crude oil has become the world most important source energy due to its high energy density and relatively easy way to recover. Fossil fuels in general had the following impacts in the past:

- Electricity generation which made large scale industrial development and transportation without animals possible;
- Supplanted water and steam powered engines;
- Supplanted combustion of wood used for heating as primary fuel.

Thus, an energy transition has taken place when black coal supplanted wood which was the primary fuel for centuries. The black coal was supplanted by crude oil and natural gas in the mid-1950’s. Black coal (used by steam powered engines) was the most important energy source until it met economical constraints. Therefore, oil and gas industry has been one of the most important industries in the past century. The living standard (of a part) of the world population is brought to a higher level. The western countries have been importing oil from the Middle East were the greatest oil reserves are located and became dependent of oil import from the Middle East. The negative consequences of being dependent of imported oil became clear in 1973 and 1979 during the oil crisis. The Middle East countries stopped the oil supply to the West as a political statement. Starting from the mid-1980’s environmental groups expressed their concerns about the CO_2 and CFC emission, global warming, environmental damages as result of fossil fuel production and applications. It seems that access to oil and finding new large resources are getting more difficult every year. Oil is a non-renewable energy source and it is about time to seek for alternative renewable energy sources. In the 1990’s the need for developing renewable energy sources has increased. However, still the majority of the renewable energy sources have economical constraints or technical shortcomings. Sustainable technology platforms and other organizations involved in this technology did not manage a successful market introduction of transportation system driven by renewable energy sources. Their vision is to bring solution to the Climate change, the emission of CO_2 and prevent environmental damages. Power and heating systems driven by renewable energy sources as for example biomass are implemented but in the developing phase (i.e. small market size).

Therefore, Strategic Niche Management (SNM) approach has been used to find out how to address the bottlenecks and how to improve the quality of the niche processes. In the last decade, the SNM approach has been studied on renewable energy sources as biomass, hydrogen-fuel and efficient use of exhaust gasses for heating which are in the developing phase. The development of new technologies takes place in a specialized environment (niche) where it is shared amongst the actors so it can be applied and tested. Strategic niche management should be used to build a proper niche environment and maintain momentum in the development of innovations of a certain specialized technological field.

In the offshore industry there is also a similar situation where a group of companies and organizations are gathered together to find fit for purpose solutions to exploit marginal fields. The required technological innovations to make exploiting of marginal oil and gas fields possible are also within a niche. Many marginal fields are technically difficult to exploit or yield not much gas in place to make great turnover within a short period.
National Oil Companies (NOC) are well aware of the environmental problems and the declining oil resources. However a small fraction of the yearly investment is for sustainable technology. The biggest fraction goes to maintaining and controlling economical potential oil and gas resources and to make money of large oil and gas reservoirs. Nowadays Small Oil companies (SOC) are taking risk to find oil and gas elsewhere or to buy matured (cream-skimmed) oil and gas reservoirs from NOC’s.

KCI bv (which is the engineering company that is interested in this research) has done many feasibility studies for these SOC’s that are interested to make profit of marginal fields. KCI bv, which from now on will be referred to as KCI, is now interested to know more about how to react or anticipate on the development of this marginal fields niche market. This research is carried out to provide KCI more insight into the niche processes during the development phase of a product. In addition, this research will also provide KCI knowledge about potential technological niches (business strategy) based on empirical approach and interviews with offshore experts.
Background

Environmental organizations and the EU parliament are increasingly concerned with respect to the CO\textsubscript{2} emission limitation in 2010 what is agreed during the Kyoto protocol. The Dutch government is not sure whether the CO\textsubscript{2} reduction is feasible although huge efforts and progress have been made to increase the percentage of sustainable technology-based transportation and energy generation. A great part of CO\textsubscript{2} emission is caused by combustion of fossil fuel during transportation and energy generation. Besides the CO\textsubscript{2} reduction what is required to stop climate change, there is a second concern that these same fossil fuel are not renewable. Sooner or later the conventional oil and gas sources will run out so there must be an alternative way to provide the world the energy sources which it increasingly demands.

Various studies have been done about how to stimulate the several innovation and technology based on alternative energy sources and how they can be introduced into the market successfully. The technical university of Eindhoven has been studying various sustainable technology approaches using the strategic niche management approach. The major conclusions were that the niche experiments were not aligned with the public domain and user at some times. The knowledge transfer and knowledge management have to be optimized. As long there is no optimization, the energy transition from non renewable fossil fuel which causes climate change through CO\textsubscript{2} emission to renewable fuel cannot take place.

The question rises what can be done to extend the use of fossil fuel for a couple of decades or more while the alternative energy sources can be optimized to achieve the energy transition successfully?

In this explorative research an answer will be given to this question. The major oil multinationals and NOC’s have not been waiting patiently on the outcomes of sustainable technology projects but have invested much money to extend the use of fossil fuel. Basically the following actions are taking place:

- New technologies have been developed to recover more fossil fuel from empty reservoirs
- New technologies have been develop to explore and recover fossil fuel from unexplored area (i.e. Arctic area and deep sea)
- New technologies have been developed to recover fossil fuel from small reservoirs

The development new technologies to provide clients with fit for purpose solutions to make exploitation of marginal fields possible are comparable to the development of new technologies to provide fit for purpose solutions for sustainable technologies. There is a niche market for these innovations however that they are not for sustaining the energy transition to alternative energy source but to continue the existing way of using fossil fuel as primary energy sources. The finding of new reserves in unexploited areas (e.g. North Alaska, Deep Sea) and better pumping technology will meet the energy demands of the coming 30 years. When the oil price keeps rising, oil recovery from oil shale and tar sands will become profitable.
1. Objective and problem definition

1.1 Objective

The objective of this research is to find bottlenecks in the marginal oil and gas niche development. A research will be carried out to find practical solutions to increase the quality of the niche processes. An improved quality of niche processes will result into an increased societal desired technology. A societal desired technology will have a successful market introduction and broader diffusion of new oil and gas technologies. The new developed multidisciplinary technologies are imbedded in the process equipment that meets the users’ requirements. During the research the conceptual framework will be used to answer all research questions. To answer these question three theories will be used during the research. The three theoretical concepts that will be used in this research are:

1. Technology commercialization (TC) theory;
2. Strategic Niche Management (SNM) approach;
3. Multi level perspective (MLP).

The technology commercialization approach will support this research with improvement of commercializing of new technologies. Activities which are considered as typical where things could go wrong will be analyzed. It should be noted that this approach will be required when the other theories cannot explain a certain conclusion.

The SNM approach has been merely used to find bottlenecks in niche experiments in relation with sustainable technology. This theory aims at learning from socio-technical factors that influence environmentally benign products during the niche development phase.

The multilevel approach is a theory that explains the dynamics during any kind of transition from an established dominant regime to a new regime.

The energy transition which implies the switch from non renewable energy carriers (i.e. oil and natural gas) to renewable energy carrier (i.e. wind-, solar- and water energy and hydrogen power system). The fossil fuel related and dependent technology is imbedded in the world of today. It is therefore very difficult to be replaced by other type of energy carriers. The oil and gas industry is a complex system with sociological and technical factors. The power of this system is sustained by the current policies and laws. The environmental laws still do not have much impact on the socio-technical system. The incremental innovation process at the moment is still winning the battle against the sustainable innovation process because the incremental innovation process fits much better in the traditional fossil fuel regime.

In this paper SNM will be carried out on technological niche markets in the traditional fossil fuel energy based regime. The factors that influence the dynamics of innovation process of offshore oil and gas recovery in marginal fields seems to have similarities with the factors that influence the dynamics of the innovation process of sustainable technology. This innovation process which belongs to the traditional fossil fuel regime is in competition with the alternative energy sources regime because it is aiming at providing more oil and gas and make cream-skimmed oil and gas fields profitable again.

In contrast to the sustainable technological niche markets, the offshore technological niche markets can be incorporated in the existing dominant fossil fuel energy regime. The seamless fit into the existing regime is a great advantage and is also slowing down the market introduction of several alternative energy sources. Hereby, new questions will arise that will be answered in this report.
1.2 *Interest of KCI engineering*

KCI is founded in 1987 to provide full engineering design and consultancy services to clients operating in onshore and offshore oil and gas industry. KCI has seen its amount of projects increasing every year. The increasing workload caused an increase in personnel in a very short time. The in-house expertise has reached also outside the oil and gas industry providing for example clients operating in the great wheel attractions sector\(^1\). In 2003 KCI became part of the international energy services company, Wood Group to enhance the range of capabilities. The combination of the knowledge of the in-house multidisciplinary engineers consisting of process, mechanical, structural, piping, electrical and instrumentation engineers and the extensive range of engineering design software have made it possible to provide a wide range of clients cost effective production applications throughout the years.

KCI is interested in this research to find a strategy based on existing theories to enhance the diffusion of its products and services. During the research only the process and the structural disciplines will be analyzed and subjected to empirical test in order to investigate the development of the technology and the factors that determine a successful market introduction. The other disciplines which are electrical and instrumentation and piping are considered during the research as not having relevant technology changes. In the following sections the process and the structural discipline will be described briefly. This section will be followed with the description of the multi purpose platform concept. This is called concept because the platform can be adjusted easily to the client’s needs and environment where the platform will be positioned.

1.2.1 *Structural discipline*

The structural department uses software to perform mandatory structural calculations. The structural department designs structures (i.e. beams, frames etc.) when small modification on a platform is necessary on existing platforms or a completely new design for a new platform. Besides the conventional structures to accommodate equipment utilized for oil and gas recovery at sea, new ideas patented by KCI are developed. The top-side and jacket\(^2\) are also designed by KCI.

1.2.2 *Process discipline*

The process department provides specialist consultancy on production, design and oil and gas separation methods. De-bottlenecking of existing process systems leads to efficient production and lower energy consumption on site.

\(^{1}\) [http://www.dubai-online.com/attractions/wheel.htm](http://www.dubai-online.com/attractions/wheel.htm)

\(^{2}\) Supporting structure for a offshore platform; source [www.premieroil.com](http://www.premieroil.com) glossary
In the table below 7 projects related to the process-structural discipline can be depicted.

<table>
<thead>
<tr>
<th>Project name:</th>
<th>Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fixed platform Q4C in the Dutch North sea</td>
<td>Wintershall</td>
</tr>
<tr>
<td>2 Re-positioning of self elevating platform within 48 hrs</td>
<td>Clyde Petroleum</td>
</tr>
<tr>
<td>3 Refurbishment fixed platform</td>
<td>Clyde Petroleum</td>
</tr>
<tr>
<td>4 Self elevating platform</td>
<td>Clyde Petroleum</td>
</tr>
<tr>
<td>5 Modification on platform to extend production life</td>
<td>Clyde Petroleum</td>
</tr>
<tr>
<td>6 Modules design for offshore platforms</td>
<td>Sable field Canada</td>
</tr>
<tr>
<td>7 Pipeline re-use/relocation</td>
<td>General</td>
</tr>
</tbody>
</table>

### 1.2.3 Process hardware for marginal fields

The competence area of KCI includes design process hardware for onshore and offshore application located in the shallow water of the North Sea. KCI has developed a range of specialized standards products for clients to enhance and accelerate the development of marginal fields both onshore and offshore. KCI has clients operating on marginal gas fields in the Dutch sector. KCI has entered the market covering basically all sectors in the North Sea and has successfully entered the global markets.

KCI wants to promote its products better in the future and wants to know: what are the reasons that some high tech products do not enter the larger market? The following process equipment is designed by KCI:

1. Subsea wellhead protection systems
2. Self installable Multi purpose platform (MPP)
3. Light weight, modular and re-usable structure for platforms

KCI is interested at the moment in a specific strategy to increase the market share of the Multi purpose platform. An oil platform is a large structure used to house machinery (equipment for hydrocarbon processing and utilities) and employees. The platform may be attached to the ocean floor, consist of an artificial island, or be floating.

When a client wants to exploit a marginal field, the feasibility of installation of the following type of platforms will be studied by KCI namely:

1. Self installing platform (MPP)
2. Conventional installed platform (i.e. installation by heavy lift vessel)
3. Subsea structure (subsea processing equipment)

In the following section the self installable platform based on the MPP concept and the subsea processing systems will be described.

http://www.cnsophb.ns.ca/generalinfo/glossary.html
1.2.4 MPP Concept

The MPP concept is development and patented by KCI. The platform is a self-elevating and self-installing platform, which is an innovative alternative to conventional platforms. During installation the complete deck is self-elevating on a purpose built jacking system supported by the four tubular. This MPP eliminates the need for clients to invest in expensive jacking systems by renting out systems, installation and decommissioning of conventional platforms. A mobile, self-elevating, offshore production platform, for exploitation of matured or smaller reservoirs, is provided with a liquid tight hull. Hydrocarbon processing equipment is pre-installed on the deck on shore. Then the platform, with legs elevated, is towed to the offshore location. On location the legs are lowered, grounded, and then pre-loaded to desired criteria by introducing ballast water into the hull. After pre-loading the platform is de-ballasted and elevated to establish a desired air gap. Upon elevation a locking device is engaged to secure each leg in place and the jacking towers, tower powering equipment and ballast pumps may then be completely removed for storage, or reuse on other platforms. Installation is completed by connecting the hydrocarbon processing equipment to influent and effluent means provided. Upon depletion of the hydrocarbon reservoir, or for other reasons such as the threat of a violent storm, the platform can be removed from one location, and reused at another, by reversing and repeating the above procedure ⁴.

1.2.5 Subsea processing system

The subsea processing system ⁵ is suitable for offshore applications at deep and ultra deep water depths including 1000 m or more, for remotely operating and processing a multiphase fluid of oil, water and gas, which may further contain solid material, such as sand particles, to be processed and separated out into its phases ⁶. Subsea processing includes:

- subsea boosting (subsea pumps);
- subsea compression (subsea compressors);
- subsea seawater injection (subsea water injection pumps);
- subsea separation (oil-gas-water separators, sand injectors, produced water injection).

Subsea pressure boosting enables longer subsea tiebacks (i.e. connection to an existing oil production platform) which enable the economics of exploiting small, remote and marginal fields. Subsea booster pumping is actually the most mature of the subsea processing technologies ⁷.

Subsea separation allows oil and gas separation at the seabed and transportation to different production facilities.

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Subsea water separation reduces the risk for hydrates formation in the flow lines. The water is removed completely from the production flow lines.

These subsea installations replace the traditional fixed platforms, where oil and gas were transported up to the platform for further processing and transport. This installation can also be used to tie-back (de-bottlenecking) to an existing platform where further processing takes place. The technology is basically an automatically hydrocarbon production and processing system below sea level instead of onshore or above sea water level (platform).

The subsea technology is not developed by KCI although in the last couple of years KCI has gained experience and know how about subsea processing systems.

In the following section the required research questions will be described. The answers of these questions will give KCI insight in the key processes required for a successful market introduction of new technologies.
1.3 Research question

The oil and gas production in the North Sea, which is very important to the Dutch economy, is declining every year. The world energy demand\(^8\) is increasing every year however major oil companies (MOC) and the policy makers are investing and promoting the use of the marginal sources of hydrocarbons. This is typical a behaviour pattern that is an indicator for resource depletion\(^9\). Nevertheless, the MOC are still investing large sums of money into the oil and gas innovation processes. Therefore, it is important to analyze the technological niche market of the marginal fields because it has a growing interest. The main research question will be defined as follows:

**How can the niche market of oil and gas of marginal fields in the North Sea be stimulated by using the strategic niche management approach?**

From this main research question the following sub questions:

1. **What is the quality of niche processes in the cases of multi purpose platform and subsea processing systems?**
2. **Which development occurs in the socio-technical regime of offshore oil industry?**
3. **How can SNM be used in the case of regime optimization?**

The questions above have societal, scientific and commercial relevance. It can contribute to the innovation studies but also to marketing studies. Thereby the influence of the society will be studied. The research questions will be answered as follows:

1. **What is the quality of niche processes in the cases of multi purpose platform and subsea processing systems?**

The key processes of a niche development will be discussed in section 2.2. The quality of those key processes will be assessed. Case 1 will be described in chapter 3 and Case 2 in chapter 4. The hypothesis that should be true is:

_A good quality of the key processes results in a successful market introduction and diffusion of the promising technology._

It is however difficult to compare qualities. The quality of key processes will be assessed by using the Key Process Quality Improvement list (i.e. KPQI list). This list is based upon literature research and the theoretical concepts. This list will be used as a research instrument (e.g. survey, observation, questionnaires, meetings and discussions).

2. **Which development occurs in the socio-technical regime of offshore oil industry?**

In chapter 6 the key processes in wider concept (regime shift and transition pattern) will be discussed. The key processes in a wider concept will also be investigated in both cases. The

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\(^8\) Source: [http://www.shellchemicals.com/chemicals/pdf/speeches/hklim_montreux_06.pdf](http://www.shellchemicals.com/chemicals/pdf/speeches/hklim_montreux_06.pdf)

\(^9\) Source: [www.peakoil.com](http://www.peakoil.com)
existing technology regime and the society can also determine whether the market introduction will be successful or not. For this the KPQI list will be used as research instrument to assess the external niche processes (i.e. Multi Level Perspective). The hypothesis that should be true will be converted now into:

*A successful market introduction requires a regime optimization. The factors within the existing regime and landscape level determine the success of the new technology.*

3. How and why can SNM be used in the case of regime optimization?

In chapter 4 and 5, SNM is used in the case of regime optimization (two case studies). SNM together with MLP will be used to indicate and explain key processes that can influence the result of the market introduction. The new technologies (i.e. MPP and SPS) that will be assessed provide regime optimization of the non sustainable industry (i.e. oil and gas offshore industry). This is completely the opposite direction of energy transition. In section 4.6, the reasons why SNM can still be used are described.
1.4 The structure of the report

This report describes first the background of this research using SNM which is a tool that is normally used to provide policy makers and organizations, interested in finding solution for climate change, and CO2 and CFC emission reduction, with critical information to make energy transition possible. Throughout these report illustrations will be added to help the reader who might not be familiar with the theory.

In the chapter 2, the conceptual framework, theoretical concepts used to answer the research questions of chapter 1 will be discussed. The SNM approach is a scientific empirical based theory used by scholars of TU Eindhoven and other universities to provide science based advice to support environmental benign technology. However this tool will be used to provide KCI insight of the dynamics that are not technology related but societal related. The author is interested in the dynamics within an incremental innovation processes within the traditional fossil fuel based regime which is still very dominant. The results of this exploratory research will lead to better understanding of the niche development of the offshore oil and gas sector. Furthermore, the theories regarding commercializing of technology and multi level perspective will also be described in order to add respectively business related point a view and societal related factors that can influence the diffusion of the new technology into the existing market. These theories together will thus be the basis of the research. In section 2.7, the collection of data will be described. This section explains how data was obtained, why that particular data was necessary and what is done with the data during the research.

Chapter 3 describes the research findings of the KCI’s product which from now on will be referred as Case 1. Case 1 is the market introduction of the Multi Purpose Platform (i.e. MPP) designed and patented by KCI. This MPP is an option for the conventional fixed platforms. The quality of the key processes of the MPP niche development will be investigated with SNM.

In chapter 4 the niche development of Case 2 will be analyzed with SNM. Case 2 is the market introduction of subsea processing systems (i.e. SPS) that KCI is interested to further develop and provide this option as a solution for clients operating in marginal fields.

In order to get more insight of the (niche) development of the products of Case 1 and Case 2, interviews were carried out with the project teams. The project teams consist of KCI employees that worked on the MPP and SPS related projects. During the interviews the quality of the key processes will be argued and discussed. The results of the research will be described in this chapter and later in chapter 9 and 10 it will be used as recommendation (KCI strategy). The answers of the questions are summarized in appendices A, B and C.

Chapter 5 starts with an introduction of the oil regime in the Netherlands and worldwide. In this chapter the Multi Level Perspective will be used to explain the key factors that influence regime optimization. This chapter will illustrate the strategies used by the oil and gas regime for assuring “oil business” continuity.
In Chapter 6 the relation between regime stability and market size change (i.e. market penetration) will be discussed by using basic terms of transition management. The relation between regime stability and market share change will be investigated and illustrated graphically. Both cases will be displayed in a transition pattern.

In Chapter 7 added value of the technology commercialization approach will be argued. In the previous chapters no attention was paid on the commercialization of new technology after the market launch. The approach of Mr. V. Jolly is used as basis of the investigation about the quality of commercialization. The results of the research described in this chapter will be used to develop a commercial strategy for KCI in chapter 8.

In Chapter 8 the results and finding will be discussed and summarized. This chapter reflects on the research by providing conclusion, answers to the research questions and recommendations. The strategy for KCI will be determined by the criteria described in chapter 2 and the results of chapter 3, 4, 5, 6 and 7. The strategy will be discussed thoroughly in section 8.3.

The appendices contain relevant information, interviews, articles and results the questionnaires.

The structure of this report is illustrated also in Figure 1.4. In the following chapter the theories that will be used to answer the research questions will be discussed thoroughly.
Figure 1.4 The structure of this report
2. Conceptual framework

2.1 Introduction

It is impossible to do research without a theory. In general, the research questions will be answered by using the theory in a practical manner to find out whether it can be used in a particular case as this. In this chapter the theoretical backbone of this research will be discussed. There are theoretical concepts available related to research on innovation. These theoretical concepts will be used to answer the research questions as described in section 1.3. The theoretical concepts used for the research are:

1. Strategic Niche Management (SNM)
2. Multi Level Perspective (MLP)
3. The 5 phases of technology commercialization (TC)

First, the strategic niche management approach (SNM) will be discussed in section 2.2. The SNM will not be used to predict the future. This approach should be used to gather information about the niche processes related to new technologies required to solve societal and technical problems. The key processes that are very important for the development of the new technological niche will be discussed in this section.

Secondly, the multilevel perspective (MLP) will be discussed in section 2.3. This approach aims to provide insights into the interaction between niche, regime and landscape.

In addition, in this section the importance of niches, how to create niches and how it will develop into dominant markets will be described. The factors causing market introduction failures will be described in section 2.4.1. When a designer wants to create a niche after a successful experiment, the SNM approach can be used to create good environment (i.e. test bed)\(^{10}\). The latter will be described in section 2.4.2.

Then, in section 2.5 the key processes of technology commercialization will be described to give the reader insight in the theoretical background about commercialization. Literally, this means getting a new technology from out of the mind, and thereafter successfully launched into the market.

The methodology will be described in section 2.6. This chapter will explain the reader how the abovementioned theoretical concepts are used in this research. The theoretical concepts are converted into key processes quality improvement list (i.e. KPQI list). This research instrument generates the required key questions that will be used during the survey, interviews, presentation and discussions. The quality of the key processes for each case depends of the data collected (see section 2.7) and answers given by the experts. The conclusion is thus related to hypothesis based on the theoretical concepts. The results of this research will be described in chapter 3, 4, 5, 6 and 7.

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\(^{10}\) A platform where testing of new technologies takes place


### 2.2 Strategic niche management

#### 2.2.1 Introduction

The SNM approach is a management tool to address the lack of broader diffusion of promising technologies. For this approach a general definition (Weber, Hoogma, Lane and Schot, 1999) for SNM is required which is defined as follows:

*The creation, development and controlled break-down of test-beds (i.e. experiments or demonstration projects) for promising new technologies and concept with the aim of learning about the desirability (i.e. in terms of sustainability or maintaining the dominant fossil fuel regime) and enhancing the rate of diffusion of the new technology.*

The SNM approach is basically aiming to create a technological niche that will develop into a market niche (i.e. applications in specific markets) and later increase in market size until it is widely accepted and adopted (see Figure 2.2.1).

![Figure 2.2.1 The ideal niche development trajectory: niche development and gain significant market share after market introduction](image)

Using the SNM approach to conduct an ex-ante analysis helps to provide insight of the future niche development of the promising technology. The SNM can also be used to find the key influences of a market introduction failure (i.e. ex-post analysis). In section 2.2 this will be discussed further.

In this chapter the SNM will be used to explain how to evaluate a market introduction (i.e. ex-post analysis) and how to conduct an ex-ante analysis. The latter helps to provide insight of the future technological niche development of the promising technology. The technological niche development can be broken down into three key processes\(^\text{11}\), which are:

- Coupling of expectations\(^\text{12}\);
- Network formation;
- Learning about problems, need and potentialities.

These key processes will be discussed in the following section because they are very important for the research.

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\(^{12}\) The prospect of the future; grounds upon which something excellent is expected to occur; prospect of anything good to come, esp. of property or rank. A less advantageous result gives rise to the emotion of disappointment. If something happens that is not at all expected it is a surprise. Source: [http://en.wiktionary.org/wiki/expectation](http://en.wiktionary.org/wiki/expectation) and [http://www.thefreedictionary.com/expectation](http://www.thefreedictionary.com/expectation)
2.2.2 Coupling expectations

The main objective of coupling expectations is to gain support from the actors involved to create the niche and subsequently to develop a marketing strategy. The value of the new technology is yet to be proven during the niche development. The expectation needs to be raised by the actors involved in the niche development.

First, the actors directly involved in the niche development should share the same expectations to avoid misunderstandings during the niche creation and development (i.e., the technological niche to market niche trajectory; see Figure 2.2.1). During this phase it is essential that the problems, expectations and tacit interest of the actors are made explicit and addressed in the network. The expectations or visions with respect to the technology may differ but the partners need to agree to a common strategy and vision. Real commitment has to be made among partners in order to achieve a targeted collaboration without setbacks. Specific mechanisms and procedures should be present to deal with changing expectations of the actors during the experimental and niche development phase.

Secondly, in order to be persuasive to potential investors and business partners the expectation should at least meet to the expectation criteria\(^{13}\), which are the following:

- Shared amongst the actors
- Credible supported by facts and tests
- Specific with respect to technological, economic and social aspects
- Coupled to certain societal problems

A dense communication structure must be available to meet the requirements of the abovementioned expectation criteria. Shared expectations can be identified when two or more actors are engaged in cooperation with the purpose to develop a niche. The expectation they share should be based on tests and facts. The tests and facts are the basis of the niche creation, which is for example: conducting research, communicate with expert/scientists or gather information. Besides these technological specifications, particular attention should be given also to the economic and social aspects because not all actors are interested in the expected technology capabilities but in the cost effectiveness\(^{14}\) and social impacts. Clear objectives and expectations associated with the niche development process will result in a wider range of actors interested in the niche.

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14 Cost-effectiveness analysis (CEA) is a form of economic analysis that compares the relative expenditure (costs) and outcomes (effects) of two or more courses of action source: [http://en.wikipedia.org/wiki/Cost-effectiveness](http://en.wikipedia.org/wiki/Cost-effectiveness)
2.2.3 Actors network formation

A crucial element in this design phase is the design of the network to carry out the experiment. The network should be broad but not too large because it will be unmanageable. The actors should provide project stability and access to knowledge and resources. There is a trade-off concerning the size of the companies involved. Small companies (SME) have fewer resources but are often better in learning and are flexible. A large organization on the other hand has more resources but brings about problems of bureaucracy and organizational conservatism. A mix of big and small companies that are committed partners is required in an actors-network because the experiment has to rely on the joint effort of all partners. The users or customers are also a part of the network because the design must meet the requirements and the needs of the (potential) users. Users should be allowed to voice their requirements critically and communicate them well to the network of actors involved in the experiment. The users’ voice must be considered as input in the design process what could result in product improvement.

The actors-network formation is required during the development of the niche. Sharing of expectation and learning experiences (see section 2.2.2 and 2.2.4) takes place within the actors-network. The network includes old and new actors from different institutions throughout the ideal niche development trajectory (see Figure 2.4). The role of the actor must be articulated from the beginning so that the actors (e.g. the project manager and planner using SNM tool) can see what type of actor is missing.

New actors may lack experience but could also introduce new ideas. On the contrary, the existing actors possess experience. However, existing actors can be locked-in, not being able to come up with new ideas. Lack of creativity will stop the niche development and the required funding. In Figure 2.4.2 the influences of learning process and expectation on the business strategy and final product are illustrated. The actors-network has influence on the expectation. The expectation has influence on the business strategy because shared expectation can lead to more funding and resources. Sharing of learning experience also can lead to more funding and resources (i.e. business strategy change). The final product (prior to market introduction) can be influenced directly by the actors within the network due to dense communication. However business strategy (i.e. more resources) has major impact on the final product.

![Figure 2.3.2 Relation between Actors-network, expectation, learning processes, business strategy and products.](image)

Formation of an actors-network provides commercial benefits to a company. Formation of an actors-network can lead to more resources (i.e. funds, knowledge, experiences and more creativity). This will enable the actors to create a better product then without a network formation. Market introduction of better production or improved products could lead to proven track record. A good track record could lead to more purchase orders from old and
new clients (i.e. more projects, more orders, and so forth.) and more funds. The actor-network will grow considerably and could interact with other markets and industry sectors. This could lead to more applications and eventually into increasing market size and power.

2.2.4 Learning processes

Through a process of learning-by-doing and doing-by-learning, knowledge could systematically accumulate, which could be used for following niche development rounds. This will result according to Kemp, Rotmans, Weterings, van der Horst (2005) in an adjustment of the agendas, perspectives, transition objectives, envisaged transition paths and experiments.

The learning process includes learning from and sharing experience by interacting with societal and technical actors. The main objective of learning is to overcome market entry barriers as for example uncertainty and lack of knowledge. The learning process is important throughout the whole innovation process because adjustment can be made on time depending of the learning curve of the actors involved in the niche development. During this niche development, which includes knowledge transfer, experiments, testing by users and finally the market introduction, the new technology experiences difficulties to be accepted and to establish due to the high barriers to entry the market (see section 2.4.1). The new technology that is a radical change cannot benefit from the conditions that facilitate the technology of the established system. According to Weber, M et al. (1999) for a new technology it will require technological, societal and organizational changes to establish in the future 15. The new technology must not only meet the requirements of the users but also must adapt to the institutional and organizational patterns or the institutional and organizational patterns should be adapted to the new technology. Also socio-cultural issues as for example way of doing things, individual preferences and customs have to be fine-tuned to the new technology in order to gain wider public acceptance. This should be taken into account up front before setting up an experiment or project. The following adjustments and articulation might be necessary when a new technology faces shortcomings, problems and barriers:

- Adjustment of the initial limitations (e.g. change of scope or specifications)
- Adjustment to be able to use the existing systems and infrastructure
- Adjustment due to production constraints
- Adjustment due to market pressures (e.g. market needs and user requirements)
- Adjustment of policy framework to make the technology viable
- Articulation of the cultural and psychological meaning (e.g. way of doing things)
- Articulation of the social and environmental benefits (e.g. political debates).

The willingness of the inventor or organization to communicate with the users and the adjustments made to overcome shortcomings, problems and barriers can let the user perceive the new technology more positively.

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2.2.5 Conclusion

According to SNM a good quality of the key processes (i.e. expectation coupling, actor network alignment and learning process) is required to achieve a successful market introduction. This hypothesis will be used during the research when using SNM as tool. Nevertheless, this seems not sufficient for this research because SNM only discusses the activities required on the niche level (i.e. bottom-up approach). It only argues that learning from society is important when a designer wants its new technology to be widely accepted by the society. The needs of the society are also linked to the existing technology. It can be concluded that in order to replace the existing technology, the new technology should respond to the societal needs. The change of societal needs will be described in the following section as the Multi Level Perspective (i.e. top-bottom and bottom-up approach)
2.3 Multi level perspective

2.3.1 Introduction

The SNM tool has provided insight into the key processes of the niche development. The SNM tool is a bottom-up approach. It only argues about the factors that the actor(s) can shape to address the lack of broader diffusion of promising technologies. SNM does not give information about the effects of the established technology (i.e. regime) on the development of a niche. The key processes of niche development do not give information about how for example legislation and economics could affect the niche development. Therefore niche development should also be investigated in wider concept (i.e. socio-technical system).

In this section SNM is considered as a part of a broader framework: the build-up of new technological regimes and the possibility of intentionally working towards desired regime change as described by Roep, Hoogma, van der Ploeg and Wiskerke (2003).

2.3.2 Multiple level model

Rip and Kemp (1998) have developed a scheme to analyze the socio-technical system where the concept of transition (i.e. regime shift from unstable regime to stable regime) is used at different aggregation levels (see Figure 2.3.2). A transition according to Geels (2002) is the result of long-term developments in stocks and short-term developments in flows. The developments take place as described later in section 2.3.4 in various domains.

![Figure 2.3.2 Multiple Level Perspective, based on Geels (2002)](image)

The multilevel perspective makes a distinction between the following levels:

1. Niches
2. Socio-technical landscape
3. Regimes
Niche
Niches also known as the micro level are domains in which new or non-standard technologies or concepts are used. It is a breeding environment where the actors can shape the product they want to introduce to the market. Companies also create for strategic reasons a niche for their new products and use the niche as a springboard to mass markets. A technological niche can be created to meet demands of local technology needs and later after some adjustments to meet international technology needs. The niche developments can be easily influenced.

Regime
The second level is the meso level of regimes. A regime is a set of dominant practices, rules, legal decision-making systems, way of thinking and assumptions imbedded in human actors that leads individual actions and public policy. The regime provides a stability and structure to the technological change and development. Only actors that can influence the outputs of legal decision-making process can influence the existing regime.

Socio-technical landscape
The socio-technical landscape also known as the macro level is a set of variables that channels the transition process. In imagery terms, the landscape refers to a land with mountains, hills and craters that dictates the flow and direction (developments towards the societal transition goal) when environmental policy measures fall as raindrop upon the landscape. The variables on the macro level that dictate the micro and meso development towards the final goal of transition policy are according to Geels and Kemp (2000):

- World view and paradigms
- Political culture and coalitions
- Infrastructure
- Social values and beliefs
- Demography
- Macro economy

The Dutch commitment to the Kyoto protocol (a societal transition goal) is a driver for socio-technical change (macro level). This results in a change in macro policies such as new regulations (i.e. meso level) that support the CO₂ reduction goals for 2010. The new regulation results in creation of niches or adjustment of a promising technology that is situated in a technology- or market niche. Thus, the way the Kyoto objectives will be reached depends of the landscape structure. It should be noted that most actors cannot influence the socio-technical landscape while on the niche level all key processes can be influenced and managed by the actors.

In the following sections the terms transition and transition management will be described. These terms will be used in case of for example energy transition. The energy transition goal can be reached by using transition management tools as described in the section 2.3.4. The transition pattern (see section 2.3.6) depends of the stability of the regime and the interest of the society in the novelty. In this research, transition patterns are much more important to investigate than the transition management.
2.3.3 Transition

Energy consumption and demand have been increasing since the industrial revolution. For centuries wood was used and was substituted by coal during the industrial revolution of the 19th century. After discovery of oil by Drake in 1859, coal has been substituted gradually by oil. The driving forces of the abovementioned transition were cheaper material and less waste.

Nowadays, growing economies of Asia like China and India (i.e. changing socio-technical landscape), force the NOC’s and other oil organizations to invest into sustainable energy (i.e. slight regime change) but also trying to increase the proven reserves by continuing with explorations and exploiting or trading marginal fields (i.e. regime optimization). Other countries which are not OPEC members (e.g. Mexico, Russia and Norway) are producing to provide the western countries as many as possible oil and gas to diminish OPEC’s market power. The oil crisis has not triggered the transition in the 1970’s and probably will not stimulate an energy transition on short notice. The established oil and gas industry always managed to come up with technical or economical solutions up till now.

The SNM approach in combination with the multilevel approach (to understand the regime shift) can be used to understand and stimulate a transition process towards a societal transition goal. According to Rotmans, Kemp, van Asselt, Geels, Verbong and Molendijk (2000) transitions are:

Social transformation processes in which society or a complex subsystem of society changes in a fundamental way over an extended period (more than 25 years)

The outcome of a transition cannot be predicted. Transitions offer the prospect of benefits, in which the development of new technologies plays a crucial role.

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16 The Industrial Revolution was a major shift of technological, socioeconomic, and cultural conditions that occurred in the late 18th century and early 19th century in some Western countries. It began in Britain and spread throughout the world, a process that continues as industrialization. During that time, an economy based on manual labor was replaced by one dominated by industry and the manufacture of machinery. It began with the mechanization of the textile industries, the development of iron-making techniques and the increased use of refined coal.


17 Source: http://www.highbeam.com/doc/1G1-80131463.html
Another characteristic of transitions is the non-linear behaviour. According to Rotmans (2000) the transition in general can be divided in four stages where the nature and speed of change differs. The four stages are:

- Predevelopment phase
- Take off phase
- Breakthrough phase
- Stabilization phase

Figure 2.3.3 Dynamic model of transitions Rotmans (2000)

It should be noted that this graph would also be used in Figure 2.3.5 to discuss the dynamic multilevel approach in section 2.3.5.

The SNM approach described in section 2.2 has been used to find out how to manage niche processes within a system innovation to broaden diffusion. The ideas about how to manage the transition process of a certain technology path can also be worked out into a management model. The latter is called transition management what will be discussed in the following section 2.3.4.
2.3.4 Transition management

An energy transition towards sustainability is a globally acknowledged societal transition goal. However, there are still major disagreements among the Western countries about how to achieve this goal and in what space of time. Energy transition is based on the change from non-renewable energy sources (i.e. fossil fuel) to renewable energy sources (e.g. fuel cells). Transition management does not consist in the planning and implementation of blueprints but in using quality images as a guide for decision-making. According to many literatures transition management is a form of management and steering involving governments, citizens, consumers, NGO’s, companies and high educational institutes (i.e. actors-network).

Dutch environmental policymakers have adopted the transition management model to develop a strategic niche management based policy to stimulate transition in energy, agriculture and transport (low emission vehicle and car sharing projects). In the 1980’s and 90’s many environmental problems have been countered by cleaner process technology, end of pipe solutions and environmental regulations. In order to comply with the Kyoto protocols much more has to be done. Changes at the customer or user side are required to meet the Kyoto protocols as CO₂ reduction. Most changes are rather incremental than radical because consumer choices are not radical. Radical choices require changes in the way of living and thinking. A relatively small portion of people are willing to change radically while the most prefer to maintain or optimize their way of living and thinking. Thus, the system is geared towards satisfying the existing and preferable customer’s choices. The customer’s needs conflicts with the environmental and societal benefits. The customers, suppliers and users are locked-in into old concepts, old problem solving methods and old technologies. This locked-in society leads to strategic actions to fight off new technologies that don’t belong to the existing system. Transition is possible after a long period with new linkages or networks, new knowledge, new concepts, different rules and new way of thinking (perception). A transition is the confluence of developments that span various systems and domains. It consists of a set of connected changes in the following domains:

- Technology;
- Economy;
- Institutions;
- Behaviour;
- Culture;
- Ecology and
- Beliefs.

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18 Rotmans, J., Kemp, R., van Asselt, M., Geels, F., Verbong, G. and Molendijk K. (2000), Transition & transition management for a low emission energy supply, International Centre for Integrative studies, university of Maastricht
20 System improvement
21 System change
All these changes are interconnected and reinforce each other. A multiple causality and co-evolution of independent development is included in the transition. According to Rotmans et al (2000), transition management is an interactive policy development towards a transition goal set up by societal actors. This will bring about socio-cultural, institutional and economic changes. The transition management has the following properties:

1. Long term think for short-term policy
2. Thinking in terms of more than one solution to reach transition goal
3. Broad actors-network
4. Use of sequential and interactive decision making
5. Aiming for learning processes
6. Bringing about system innovation rather than system improvement
7. Managing and steering a range of options

In order to determine an ideal transition management the abovementioned properties should be identified. The Transition Management (TM) towards sustainability is a managing and steering of system innovation related technological options. During this particular research the TM will be used as system optimization management tool. The latter includes all properties of TM except for property number 6. In this research, the system optimization management will bring about system optimization. The system optimization will be articulated as strategy of the dominant regime. Social transformation is not expected to occur because new promising technologies required for system optimization don’t require significant social transformation. It can be concluded the transition goal set up by the societal actors is system improvement. Furthermore, system innovation and system improvement require good management practice. The reason for this is that the introduction of radical or incremental innovation has to deal with dynamic processes that can influence the result of market introduction.

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2.3.5 Dynamic Multiple level model

In the multilevel perspective, the evolution of macro-variables have great influences on the technological niches or local initiatives that may result in a transformation of the existing system (i.e., regime shift). A dynamic pathway of transitions is characterized by an S curve (see Figure 2.3.5).

Innovations do remain for a long time (in some cases a couple of decades) in the micro level before it is able to take-off and breakthrough the meso and macro levels. The breakthrough occurs when the technological niche can provide solutions to problems on the regime and socio-technical landscape level (i.e., society needs). During the meso level breakthrough the regime changes (e.g., policy change) to facilitate the diffusion of the emerging promising technology. Thus, the presence of problem-solving technology (e.g., that makes lower energy prices possible) has weakened the existing regime. At the same time the socio-technical landscape has changed (e.g., because of the high energy prices the new technology gets political support) to facilitate this technology. The regime shift takes place gradually and eventually will become stable. Thus, the regime shift takes place when the socio-technical landscape is changed. The regime will change until it fits into the new socio-technical landscape. This multi-level change process is dynamic; long-term developments in stocks and short-term developments in flows as described by Geels (2002). In the following section, the process of regime change and diffusion of new technologies will be described. This information is required for the regime analysis, which is a part of the MLP.
2.3.6 Transition patterns

In section 2.3.5 the dynamic multilevel approach is discussed. The technology emerged in a stable regime situation. Only improved technologies can manage to achieve significant market share. What if the technology emerges into an unstable regime?

Therefore, Geels (2002) and Raven (2005) introduced a two by two matrix to include emergence of promising technology into an unstable regime. The horizontal axis indicates the moment (early or late) emergence of new functionalities while the upper vertical axis indicates the stable regime situation and the lower axis the unstable regime situation. In this research the relation between regime stability and market share change (i.e. product diffusion rate) will be investigated. It should be noted that regime change is more likely to happen when the existing regime is unstable (i.e. hypothesis). However, that is not always the case because the diffusion rate may remain low or decrease due to for example the fierce competition with other emerging new technologies, perceived low added value of the new technology or the new regulations (landscape level) give the new technology insignificant advantages.

There will be four patterns which are:

1. Low diffusion and stable regime
2. Low diffusion and unstable regime
3. High diffusion and stable regime
4. High diffusion and unstable regime

The indicator for diffusion is the market share. When a product remains in a technological niche phase after the market launch, it will be considered as low diffusion. On the contrary, when the market share increases significantly (i.e. market niche or market share), it will be considered as high diffusion. The regime becomes unstable when the socio-technical landscape has changed. The indicator for regime instability are change in oil price, changes in oil demand and opportunity for new technology due to the shortcomings of existing technology. The matrix that will be used is depicted below. The matrix will be explained further in section 2.6.8 and the results of the research showing the transition patterns in chapter 6.
Figure 2.3.6 Four patterns in phases of transitions based on Geels (2002)

### 2.3.7 Conclusion

In this section the MLP described that a successful market introduction of a new technology (micro level) depends on the changes on the landscape level (macro level), and also changes of the needs of the society or regime (meso level). When the change of the society is radical as for example the use of sustainable energy, it is called transition. The way to monitor and manage the transition is discussed in the section 2.3.4. How and when transitions occur is described in section 2.3.6 by using a two by two matrix that is based on the matrices of Geels (2002) and Raven (2005). The indicators are explained however the characteristic of each quadrant of the matrix will be explained in the methodology chapter. The indicators and the characteristic of each quadrant will determine the position of a new technology. This is the additional information (i.e. transition pattern) provided by the MLP. The transition pattern illustrates the status of the new technology after the market launch.

In the following sections the theoretical background of SNM and the factors causing market introduction will be discussed. These are issues related to SNM and MLP discussed respectively in section 2.2 and 2.3.
2.4 *Theoretical background of Strategic Niche management*

This chapter is included in this paper in order to understand the SNM literature and theories used as tool to analyze the traditional fossil fuel regime of which KCI as an organization is a part of.

SNM will be used as an operational tool to identify factors that can cause market introduction failures. In section 2.4.1 this will be discussed thoroughly.

According to van Mierlo (2002) SNM could be used to manage the innovation processes during the experimental phase or pilot projects. How a technological niche should be created will be discussed in section 2.4.2.

2.4.1 Factors causing market introduction failure

As stated previously, the rate of diffusion of a new technology can be increased with the help of SNM. The diffusion rate of a new promising technology in general fails for a number of reasons. Weber, Hoogma, Lane & Schot (1999) introduce the most common reasons why innovation experiments or market introduction fail, which are:

1. Technological barriers
2. Policy failures
3. Underdeveloped market and infrastructure
4. Uncertainties of benefits
5. Socio-cultural barriers (e.g. habits and preferences)

**Technological barriers**

The existence of companies already operating in the industry can make the entry of a new technology extremely difficult. These companies protect their revenues and profit because they could be having strong customer loyalty or patents. Government intervention (by introducing alternative regulation) is a common remedy for technological barriers.

**Policy failures**

When the government has introduced a badly designed regulatory alternative a desired outcome cannot be achieved. The policy can thus be a reason that a promising technology cannot be introduced to the market successfully.

**Underdeveloped market and infrastructure**

Timing is also very important. Promising technologies often need a developed market and infrastructure in order to achieve a technology breakthrough so a significant step towards commercialization can be taken.

**Uncertainties of benefits**

Knowledge about the benefits of using a promising technology plays a crucial role in diffusion of the promising technology through an existing industry. When the potential users are uncertain of the benefits the diffusion will not take place.

Social and cultural barrier
In general societal groups by means of protests and cultural barrier, which is related to the way of doing things can stop the diffusion of the promising technology.

Under-investment is not a plausible reason because technology diffusion is also lacking for a number of over-invested experiments. The abovementioned factors are interrelated and reinforce each other throughout the innovation process. In this research the common reasons why innovation will be investigated.

SNM approach claims that it will avoid these barriers that cause market introduction failures. The way to do this with SNM is explained in sections 2.2 and 2.3.

2.4.2 Creating a technological niche

The SNM approach will be used to prevent new technologies from bumping into market entry barriers as described in section 2.4.1. When a concept or idea is ready to be proven by an experiment, the designer has to take into account that it will be a piecemeal development at the beginning. Nevertheless the main objective is to create a technological niche\(^\text{25}\). The first step is thus to create a technological niche which is situated between variation and selection environment (Raven, 2005). Thus, located between the Research and Development organization where variations takes place and market niche were the final selection takes place. In the following sections the way to experiment (i.e. creation of a technological niche) according to the SNM tool will be discussed. The experimental phase can be divided into 5 stages which are:

1. Identify a new technology or concept
2. Design an experiment
3. Implement an experiment
4. Expand an experiment to a technological niche
5. Review of the protection of an experiment

2.4.2.1 Identify a new technology or concept

An experiment can differ slightly from the established technology because its contribution is a minor change. However, an experiment can also differ in many respects from the established technology because a radical change is required. The inventor or organization should take into account that experiments that slightly differ from the established technology are more likely to get support because of the low risk. When an inventor or organization has challenging objectives (e.g. sustainable transport systems) in mind, it will not be easy to persuade users to cooperation due to the high risk.

Bearing these in mind, decisions need to be made to select one technology or to keep a number of options open. The latter is preferred to avoid the risk of lock in to an early decision path. It should be noted that once a path is chosen it is difficult to switch to another path (path dependency). When more options are open, the inventor or organization is capable of making better decisions because early choices lead to strong path dependencies. Too many

\(^{25}\) Ieromonachou, P., Potter, S & Enoch, M., (1998) Using strategic niche management to evaluate and implement urban transport policy instruments, Centre for technology strategy, The open University, United Kingdom
experiments at once can also bring about more uncertainty due to slow progress or lack of overview.

2.4.2.2 Design an experiment niche

Once the promising technology or concept has been identified and selected, an adequate protective environment can be designed. A good balance has to be found between overprotection and minimum level of protection to make further development of the technology in the market environment possible. The protected situation can be a chosen application, geographical spaces (remote area or city) or at a chosen company. Also subsidies (government support), patented technology and regulations (government support) can be applied to achieve protective spaces. Thereby, a mix of big and small companies and institutions that are committed partners is required because the experiment has to rely on the joint effort of all partners. The latter will be referred to as actors-network as described in section 2.2.3.

2.4.2.3 Implementing an experiment

The wider public can also be affected by implementation of the new technology. The wider public can be represented by:

- Political actors;
- Neighbourhood organizations;
- Trade organizations.

Opposition of wider public can slow down or stop a technological niche development. Therefore, implementation of an experiment is offering sceptical users an opportunity to see the benefits of the promising technology. It is also an opportunity to meet potential users and to gain more resources. After this demonstration of the prototype the inventor or organization can review it or decide to formulate an ambitious plan for further development and create the technological niche.

2.4.2.4 From experiment to technological niche

When moving from small to large scale the decisive factor for progress and success will change. The composition and the amount of organization involved in the niche will also change and there will be other expectations and visions injected by the new actors. New actors are required after the up scaling because they give more momentum (i.e. more knowledge, more resources or more experience).

Another important issue is to try out other applications or another market segment. The actor network will be broadened and the chance for product diffusion will be greater. Other applications will result in other type of users’ requirements. The technology or concept needs to be customized because the new users of the mass market are less tolerant than the users of the pioneer market.
Once the technology is implemented at large scale it becomes in touch with wider social, economic and political forces. Recognition at governmental institutions and wider public may be very important after the scale up. At this phase complementary policies could be conducive, needed or detrimental to the experiment.

2.4.2.5 Review of the protection of the experiment and technological niche

According to Weber et al. (1999) the experiment protection differs from technological niche protection. An experiment benefits from specific protection measures while the niche benefits from the specific adjustment of the policy and regulatory framework. A phased breakdown of protection is an important aspect of an experiment. The experiment has been successful when it does not need protection measures any more. The improvements and learning processes have made it possible that the experiment can survive under unprotected conditions. Ambitious follow-up planning is necessary to create and maintain sufficient momentum in terms of support and resources. Experiments showing good results can play a useful role in delivering valuable insights for a new experiment or market niche. However, bad results can stop the niche development process.
2.4.3 From technological niche to market niche

According to Weber et al. (1999) a good niche formation will lead to a product that is ready to enter a market niche and the product supplier obtains more insight in the market development. A good market strategy is required at this stage. An organization that implements a good market strategy while launching its new technology to the market will have influence on the established technology. The new technology can be perceived as the technology of the future. When it is a radical innovation, the existing policy and regulatory framework should be adjusted to meet the requirements of the new technology. This is called regime change in section 2.3.

A bad market strategy leads to an unsuccessful market introduction. Weber et al. (1999) introduced three possible patterns of development, which they applied to the electric road vehicles research. After creation of a technological niche the following three developments can take place:

1. Technological niche proliferation
2. Market niche
3. Regime transformation

Technological niche proliferation
A niche development can result in a reinforcement of an existing technological niche. In this case the market share does not increase because the existing regime becomes much better in meeting societal and technological demands. In this case, policy and regulatory framework adjustment fail to trigger a market size increase of the niche. This pattern (see Figure 2.4.3.1) will lead to more technological niches or funds for more experiments but no market size decrease of the existing dominant regime.

![Figure 2.4.3.1 Patterns of development 1: Technological niche proliferation (Weber et al., 1999)](image-url)
**Market niche development**

A restricted number of users switched to the new technology. However, this hardly affects the existing regime because the scale and scope of the newly created market niche are limited. Nevertheless, the demand will increase and more investment will be channelled into research and development organizations and new high-technology industries (see Figure 2.4.3.2).

![Figure 2.4.3.2 Patterns of development 2: Market niche development (Weber et al., 1999)](image)

**Regime transformation**

A combination of market niches and product diffusion rate which results in an increasing market share. The established technology is losing ground and will be substituted by the new technology. This pattern (see Figure 2.4.3.3) will lead to regime transformation. The new technology will develop into the new dominant technology and the old technology will become a “niche” (only used for specific purpose).

![Figure 2.4.3.3 Patterns of development 3: Regime transformation (Weber et al., 1999)](image)
2.5 Five stages technology commercialization

2.5.1 Introduction

In section 2.4.1 the factors causing market introduction failures was discussed. The SNM approach and the multilevel perspective were used to address societal and technological problems that the new technology faces during the niche development. These theories also lack information about market strategy and how to deal with competition within technological and market niche. The SNM approach and the multilevel perspective cannot generate plausible reasons for the failure of incremental innovations that don’t require societal influences. The process of commercialization of Jolly (1997) is given in Figure 2.5.1. This will be used as additional key processes required for a successful market introduction. There are more reasons that new technologies do fail. These can be:

- Because new technologies got incorporated in products for which the market introduction was a failure;
- The new technologies did not get the chance to get incorporated into any suitable products at all;
- The promised demand cannot be met due to insufficient interest and resources.

V.K. Jolly (2000) has studied several new technologies and mentions the following activities, which are considered as typical where things could go wrong:

1. The linking of a technological discovery to a worthwhile and exciting market opportunity;
2. Having the technology endorsed early by those whose opinion matters;
3. Incubating the technology sufficiently to understand its true potential, including whether it will ever be cost-effective enough to merit taking further;
4. Mobilizing adequate resources for its demonstration;
5. Successfully demonstrating the technology for the context in which it is to be used;
6. Mobilizing the market constituents needed for gaining market acceptance and delivering the benefits of the technology;
7. Promoting the final products and processes to an often sceptical customer group;
8. Choosing an appropriate business formula for gaining access to the required business system;
9. Sustaining commercialization so as to realize value from the technology after it has been launched.

Jolly (2000) has introduced technology commercialization. This is about performing a range of things successfully by continuously adding value to the technology throughout
the process. Furthermore, Jolly (2000) characterizes the technology commercialization as a dynamic process that proceeds through five stages, which are:

1. imagining
2. incubating
3. demonstrating
4. promoting
5. sustaining

In the following sections, the five stages will be explained to understand the technology commercialization much better. The process of technology commercialization according to Jolly (1997) is given in the figure below.

Figure. 2.5.1 The process of technology commercialization; source: Jolly (1997)

2.5.2 Imagining

Commercial value in the technology starts when a new technology gets elucidated with confidence. The dual insight: the combination of technology and market insight is very important in this pre-commercial stage. The organization must have sufficient knowledge in house. This in house knowledge includes:

- science-based knowledge;
- existing hardware specifications;
- knowledge of patented technologies

With these abovementioned knowledge, a new principle or hypothesis (technology needs) linked to the market needs and users’ requirements can be formulated. A good formulation creates an image that requires further commercialization until the image is converted into hardware. Now, the investor must think a step ahead to avoid that the new idea lies idle for years waiting for commercialization. The idea should be converted into a project worth pursuing and proving sceptics wrong. When the organizations don’t take opinion leaders seriously the chances are that the hardware will not be accepted and that the inventor will have a major setback in the innovation process.

2.5.3 Incubating

A great amount of resources and time have gone into the imagining stage and the conversion of idea into a project worth pursuing. In this incubating stage more resources and time will be required. At this step the organization should decide how to take this technology further and if taking greater risks is worthwhile. For big companies that have more than one new idea, this is the stage where several projects will be assessed for best market potential. For an inventor, it is time to persuade stakeholders or companies to take this idea further. In both cases, incubating involves bringing the technology further by demonstration projects (e.g. building prototypes). In this phase the organization is building expected values in the eyes of those whose support is sought. In general, the expected value is judged by the size of the expected pay-off and the probability of realizing it in a reasonable time frame.

2.5.4 Demonstrating

A demonstration is an opportunity of the inventor or organization to translate conceived applications into concrete products. Besides finding financial resources for demonstration, the context and capabilities are also important. Context relates to concrete product opportunities and knowledge of what to demonstrate and how. Capabilities refer to the research infrastructure and skills required for bringing together enabling technologies and performing product development efficiently. They include not just R&D but, project management skills, ways to integrate marketing and manufacturing considerations and dealing with a host of suppliers and research partners. The simultaneous need for capital, context and capability explains why many inventors or organization prefer partnerships with large, experienced companies.
2.5.5 Promoting

A well-conceived and demonstrated technology creates its own technology pull. A promotion strategy should educate the market and influence opinion leaders.

In practical terms the products will be adapted to stimulate demand by:

- exercising flexibility in positioning the technology;
- pricing for early adoption;
- targeting the technology to receptive segments;
- building an effective communication;
- influencing the strategy to gain wide acceptance as quickly as possible.

2.5.6 Sustaining

After the new technology have been developed and launched, the real pay-off comes after the launch. The latter depends of the attractiveness of product or process innovation and the product diffusion after the market introduction.

In the post-launch phase the following activities are very important:

- Solving customer/user problems
- Upgrading or maintenance of the product
- Monitoring market trends
- Developing life extension

Solving customers or user problem is a way to maintain the interaction between user and fabricator/inventor that have been built to meet the user needs during the experiment phase.

Upgrading and maintenance are also important activities because it is a way to lock in the user into the product. The dependency will maintained or increase through the years. Market monitoring is an important activity because market dynamics have great influence on the product. When the demand is high the price per unit product will decrease or prices of other product can also influence the customer behaviour. Therefore proper measure should be taken to keep the customers or users focused on the product. There is also a threat of substitution after the launch; therefore three activities have to be taken into account to assure life extension of the product. The three activities are the following:

1. Entrenching the product or process in the market to create condition for the technology to have a long life;

2. Expanding the use of the product by introducing it to new or other (market) segments or new applications.

3. Dominating the critical facets of the technology to secure long-term profits for the inventor.

The best way of entrenching the products or process is to make quick technology progress and monitoring the better value-cost relationship. Expanding the use and dominating the critical facets depends more of the inventor-customer relationship. Searching for new market
segments and finding new applications is a process in which potential users are identified and persuaded to use the technology. Dominating critical facets of the technology includes patented technology or licensed production.

2.5.7 Conclusion

The 5 stages of technology commercialization approach can be used to emphasize the market strategy, commercial and economical issues. Although, the imaging, incubating, demonstrating and promoting stage are already incorporated in the SNM approach as respectively creation of a niche and key niche development processes (coupling expectations, learning processes and actors-network formation). The sustaining stage is not covered by the SNM approach neither the multilevel perspective. In order to assess the process of commercialization, a technology commercialization checklist will be generated. This checklist will be used to find out to what extend the commercialization process has been applied. The checklist consists of the activities, which are considered as typical where things could go wrong according to Jolly (1997). The key processes that determine the quality of each of the 5 stages of technology commercialization (i.e. TC) will be added into the key processes quality improvement criteria. Both TC checklist and KPQI list will be discusses in the following sections.
2.6 Methodology

2.6.1 Introduction

The purpose of the technology that will be studied is rather incremental than radical. A radical innovation is for example sustainable energy technology. Radical innovation and changing the way of doing things (e.g. driving zero emission vehicles or car sharing) require changes in the regime and landscape as described in section 2.3.

The reason for using the SNM in this paper on the traditional fossil fuel regime is not to promote an energy transition but to convert a promising technology into to a more widely used and socially accepted technology. Two cases will be subjected to the theories described in the previous sections. In the following sections it will be explained how the research questions related to the cases will be answered and how the required information to answer the questions is obtained.

2.6.2 Case 1: Multi purpose platform (MPP) concept

The SNM approach will be used to assess the market introduction of the MPP (multi purpose platform developed by KCI in the end of the 1990’s). Thus, an ex-post analysis will be conducted on this case. The multi level perspective will explain the requirements for a regime transformation and the technology commercialization will explain the market strategy.

The market introduction of the MPP developed according to patterns of development number 2; market niche development (see Figure 2.4.3.2). This is characterized as a restricted number of users that switched to this MPP (new technology). However, this hardly affects the existing regime because the scale and scope of the newly created market niche are limited.

2.6.3 Case 2: Subsea processing system technology

The SNM approach will be used to assess the market introduction of the subsea technology. Thus, an ex-ante analysis will be conducted on this case. To explain regime transformation the multilevel perspective will be used and commercial issues will be explained with the 5 stages of technology commercialization.

2.6.4 Case studies

Both cases will be investigated whether SNM and MLP where applied during the pre-market launch phase. When applications are discovered, the quality of the key processes will be analyzed in order to find recommendations. A key process improvement criteria is generated before starting with the collection of data. These criteria will be described in section 2.6.6.

Both cases will also be investigated whether the technology commercialization is applied during the pre-market launch phase. The checklist of successful commercializing will be used as framework to identify, which stages have been executed and which stages have not been executed. The checklist is described in section 2.6.7.

The data collection for both cases includes literature research, surveys and interviews with technical experts involved in the development of the new technologies. The key process
improvement criteria and the technology commercialization checklist are the basis of the research. The hypotheses are used as measurable variables (i.e. good or bad quality classification).

2.6.5 SNM analysis

The SNM approach for both cases is depicted in Figure 2.6.5 below. The MPP and the Subsea processing systems niche development can be assessed. KCI can learn from the SNM ex-post analyses and make improvements in the new generation of MPP’s. Before initiating the new generation MPP niche development it is recommended to pay attention to the niche creation and technology commercialization stages. An ex-ante analysis should be conducted and during the niche development the key processes (actors-network formation, expectation and learning processes) should be of good quality.

![Strategic Niche Management Diagram](image)

Figure 2.6.6 SNM used as evaluation tool (ex-post analyses) and as niche creation and niche development planning tool (ex-ante analyses).

In order to obtain the required information to verify answers found in the literature or on internet, a Key processes quality improvement criteria (KPQI) model is generated. The KPQI is a summary of measures to address market entry barrier, slow learning progress, low expectation and actors-network. The Successful Commercializing checklist is to address commercial issues that are not covered by the SNM approach and the Multi level perspective. The following sections will describe the KPQI and the Commercializing checklist.
2.6.6 Key processes quality improvement (KPQI) criteria

In this section a criteria will be determined so it can be used to determine to which extend an experiment or technological niche development can be perceived as a success. This KPQI list will be used to set up a survey, interview or the do literature research. The question codes will be used in the questionnaire (see appendix A and B) and also in the graph that displays the responses (see appendix C). It can also used to create performance indicator by adding weighing factors. During the research all item will be classified as good or poor quality.

The hypothesis is: a good quality of key processes (i.e. expectations, actors-network and learning process, regime optimization and technology commercialization process) will lead to successful market introduction of a new technology. When all or a significant amount of the key processes given in the table below has taken place during the niche development, the new technology will have a successful market introduction.

Table 2.6.6.1 KPQI criteria based on the SNM approach for monitoring niche developments

<table>
<thead>
<tr>
<th>Take measures against technology barriers</th>
<th>Question code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use existing knowledge as patents to gain time and speed up the development process</td>
<td>TB.4, AN.4</td>
</tr>
<tr>
<td>Contact external advisors for both commercial and socio-technical advise</td>
<td>TB.1, MLP.2</td>
</tr>
<tr>
<td>Study the possibilities and options by using the current political policy and regulations. Also try to predict what kind of technology will emerge as result of a macro political decision or change such as Kyoto protocol</td>
<td>TB.2, MLP.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Take measures against lock-in or paradigms by learning and adjusting</th>
<th>Question code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact the users or customers on a regular basis to monitor the user requirements</td>
<td>LP.1</td>
</tr>
<tr>
<td>Take into account that regulations and political policies can results in scope changes.</td>
<td>LP.3</td>
</tr>
<tr>
<td>Study the possibilities and options by monitoring the competition performance on the market.</td>
<td>LP.5</td>
</tr>
<tr>
<td>Study the possibilities and options by monitoring the conventional technologies to create radical or incremental innovation that can be integrated in the existing situation which is easy for the potential user to adapt to the artefact.</td>
<td>LP.6</td>
</tr>
<tr>
<td>Study the possibilities and options by monitoring other market segments. Knowledge and technology can be used for other purposes.</td>
<td>PO.1, MLP1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Take measures against low expectations during the project or experiments</th>
<th>Question code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make problems, expectations and interest explicit and address it in the actor network</td>
<td>VE.2, MT.2</td>
</tr>
<tr>
<td>Make sure that the interpretations or visions of how the technology should look like and should perform, is shared in the actor network. To avoid setbacks the partners should agree to a common goal.</td>
<td>VE.1</td>
</tr>
<tr>
<td>Testing and demonstration projects are a way to strengthen the motivation of non-supporting actors. These actors may be very important during market introduction.</td>
<td>VE.4, MT.3</td>
</tr>
<tr>
<td>During the development phase the commitment by all partner institutions should remain high to pursue projects goals collaboratively.</td>
<td>PO.3, PO.4, AN.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General SNM checklist</th>
<th>Question code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up a selection criteria to make choices between technical options</td>
<td>SP.1</td>
</tr>
<tr>
<td>Set up an actor network analysis based on the multilevel perspective. The actor network will be different for all three levels</td>
<td>AN.1, MT.2</td>
</tr>
<tr>
<td>Set up a list of potential non supporting actors that can influence the market introduction</td>
<td>AN.3</td>
</tr>
<tr>
<td>Set up a list of regulations and other socio-technical factors that can influence the market introduction</td>
<td>LP.3, MLP.4</td>
</tr>
</tbody>
</table>

CO₂ injection and underground gas storage can be regarded as oil and gas technologies used as CO2 reduction technology and structural calculations and concepts applied for the great wheel projects
### Table 2.6.6.2 The sources of the KPQI criteria

**Take measures against technology barriers**

|   | Strategic Niche management approach – Key process: Learning process  
|   |   Good example: trucks on railroad wagons in North Sweden; partners were freight division of SJ and food retailer ICA.  
|   |   Thanks to good cooperation the experience proved highly successful according to Weber et al. (1999)  
<table>
<thead>
<tr>
<th></th>
<th>5 stages of technology commercialization – Pre-commercial and Imaging stage (Understanding of principles) (Jolly. V 1997)</th>
</tr>
</thead>
</table>
| 2 | Strategic Niche management approach – Key process: Actors- network  
| 3 | Strategic Niche management approach – Key process: Learning process  
|   |   Multi Level Perspective – Landscape change |

**Take measures against lock-in or paradigms by learning and adjusting**

<table>
<thead>
<tr>
<th></th>
<th>Strategic Niche management approach – Key process: Learning process/coupling expectation</th>
</tr>
</thead>
</table>
| 1 | Strategic Niche management approach – Key process: Learning process  
|   |   Example: The Bikeabout project (Portsmouth, UK) will have been a great success if policymakers managed to intervene with a policy that implemented restrictions to car drivers while offering bicycles as alternative travel mode.  
|   |   Multi Level Perspective – Technological regime |
| 2 | Strategic Niche management approach – Key process: Learning process  
|   |   5 stages of technology commercialization – Promoting stage: targeting the receptive segments |
| 3 | Strategic Niche management approach – Key process: Learning process  
|   |   5 stages of technology commercialization – Promoting stage: Adapting the product conforming to existing patterns of use (Jolly. V 1997) |
| 4 | Strategic Niche management approach – Key process: Learning process  
|   |   5 stages of technology commercialization – Sustaining stage: Expanding the use of the product and knowledge (Jolly. V 1997) |

**Take measures against low expectations during the project or experiments**

<table>
<thead>
<tr>
<th></th>
<th>Strategic Niche management approach – Key process: Expectation coupling</th>
</tr>
</thead>
</table>
| 1 | Strategic Niche management approach – Key process: Expectation coupling  
|   |   Good example: Large scale experiment with LEV's in Mendrisio, Switzerland; Objective: increase electrical vehicles in Switzerland; Monitoring all partners to assure that all partners shared the same expectations, Weber et al. (1999) |
| 2 | Strategic Niche management approach – Key process: Expectation coupling  
|   |   5 stages of technology commercialization – Demonstrating stage: Mobilizing resources for demonstration and stages in the demonstration of a technology (Jolly. V 1997) |
| 3 | Strategic Niche management approach – Key process: Expectation coupling  
|   |   5 stages of technology commercialization – Demonstrating stage: Mobilizing resources for demonstration and stages in the demonstration of a technology (Jolly. V 1997) |
| 4 | Strategic Niche management approach – Key process: Actors- network/Coupling expectation |

**General SNM checklist**

|   | Strategic Niche management approach – Key process: Learning process (learning from users)  
|---|---|
| 1 | Strategic Niche management approach – Key process: Learning process (learning from users)  
|   |   Good example: Large scale experiment in Mendrisio in Switzerland provided a forum for to compare many types of LEV's and an assessment of people's mobility patterns and learning processes was conducted. Weber et al. (1999) |
| 2 | Multi Level Perspective – find actors that can influence the niche level, technological regime level and socio-technical landscape level. This is required for regime shift. |
| 3 | Strategic Niche management approach – Key process: Actors- network (anticipate opposition from NGO's and the general public) |
| 4 | Multi Level Perspective – factors that can be influence the regime (i.e. optimization or change depends of the purpose of the promising technology. For offshore technology it will be regime optimization when it is compared to sustainability and regime change when a new technology should replace conventional technology) |
2.6.7 Technology commercializing checklist

In this section the phases described by Jolly (1997) are summarized. This should be used as checklist starting from niche creation until after the market introduction. The commercialization processes of MPP-niche are assessed using the table below as stepping stones to the questionnaires, surveys and literature research. The question codes refer to the questions used to collect data for this research.

<table>
<thead>
<tr>
<th>Commercialization process</th>
<th>Question code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Link the new technology to a worthwhile and exciting market opportunity</td>
<td>MLP.4</td>
</tr>
<tr>
<td>2 Endorse the new technology by opinion leaders in the pre-development phase</td>
<td>MLP.3</td>
</tr>
<tr>
<td>3 Incubate the technology to understand its potential regarding to cost-effectiveness</td>
<td>TB.1</td>
</tr>
<tr>
<td>4 Mobilize adequate resources to make demonstration projects possible</td>
<td>AN.2, AN.4</td>
</tr>
<tr>
<td>5 Demonstration of the technology</td>
<td>MT.3</td>
</tr>
<tr>
<td>6 Mobilize the market constituents needed for gaining market acceptance</td>
<td>AN.1, AN.3, MLP.2</td>
</tr>
<tr>
<td>7 Promote the final products and process to sceptical users or customers</td>
<td>MT.2</td>
</tr>
<tr>
<td>8 Choose an appropriate business formula for gaining access to the required business system</td>
<td>MT.1</td>
</tr>
<tr>
<td>9 Sustain the commercialization so as to realize value from the technology after it has been launched.</td>
<td>MLP.1</td>
</tr>
</tbody>
</table>

---

### 2.6.8 Transition pattern matrix

The transition pattern matrix as discussed previously in this chapter is characterized as given in the figure below. This matrix describes the regime stability and market size after the launch.

<table>
<thead>
<tr>
<th>Market size decrease</th>
<th>Market size increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable regime</td>
<td>Stable regime</td>
</tr>
</tbody>
</table>

1. Regime: no incentives to invest.
2. Actors: very low expectation about future potential.
3. Market remains small and offers no threat to the existing regime.

1. Regime: weak incentives to invest although there is growing interest in the new technology.
3. Market size of the new technology increases or decreases due to the fierce battle with the existing regime.
4. Development phase: Market niche (co-existence or regime transformations takes place).

<table>
<thead>
<tr>
<th>Unstable regime</th>
</tr>
</thead>
</table>
1. Regime: looking for new technologies to solve existing problems. This leads to strong incentives to invest.
3. Market is growing and offers significant threat to the existing regime. The new technology is linking up gradually to the ongoing processes.
4. Development phase: Market niche (co-existence or regime transformations takes place).

1. Regime: the new technology substitutes the existing technology to solve specific problems that the regime faces. Strong incentives to invest
2. Actors: high expectation about future potential.
3. The new technology is capturing major market share.

Figure 2.6.8 Characteristics of the Four patterns of transitions based on Geels (2002).
2.6.9 Conclusion

The methodology described the conceptual design of this research.

The SNM key processes (expectation, actors-network and learning processes) discussed in section 2.2 will be used to analyse the MPP and SPS. The results of the key processes quality analysis will be discussed respectively in chapter 3 and 4.

The Multi Level Perspective (niche-, regime- and socio-technical landscape level) discussed in section 2.3 will be also used to analyse the regime optimization and transition patterns of the MPP and SPS. The results of the regime optimization and transition patterns will be discussed respectively in chapter 5 and 6.

The technology commercialization processes according to Jolly (1997) as discussed in section 2.4 will be used to analyse the commercialization process for MPP and SPS. The results will be discussed in chapter 7.

The KPQI list and Commercialization checklist will be used throughout the research to find answers about both cases with respect to the theoretical concepts. Both lists will be used as basis of the interviews and survey. It will be recommended to use these questions to monitor for example the key processes of niche development, affects of macro-economics and regimes (MLP) and to improve commercialization. The added value of the commercialization processes will be discussed in chapter 7 also.
2.7 Data collection

In the previous sections the theoretical concepts and the list of required information to do this research was described. The KPQI list and the TC checklist will be the stepping stones to the required information for both case studies. The information acquired will be discusses in chapters 3, 4, 5, and 6. The conclusion of the research will be described in chapter 8. In this section the data required to do this research will be described. Data (i.e. evidence) should be collected in order to support this research with arguments. As argued by Raven (2005) a collection of data (i.e. multiple sources of evidence) should be combined by the researcher into a fact. For this research the following sources are used to collect data:

- Articles from the media (newspaper)
- Internet sites
- Brochures of companies
- Articles from scientific journals
- Minutes and slides of meetings
- Annual reports

Media Articles
Media articles regarding newest and relevant offshore technologies were analyzed and used as the latest updates of oil and gas technology for this paper. An example of a media article is the claiming of an Arctic region by Russia by planting a Russian flag in the seabed. Russia wants to explore for oil because that area is in their territory.

Internet pages
Internet pages were found by using http://www.google.nl and searching for strategic niche management and oil and gas technology related web pages. The internet pages accessed are added in this paper as footnote and also listed in reference section. During the research, internet sites of major oil companies, financial institutions, national governments, oil and gas journal, offshore industry journals, research institutes, environmental NGO’s, Dutch energy companies, universities and European/American patent databases, were used to collect wide range of information.

Company brochure
Brochure’s of companies which were available online have been downloaded and analyzed. These brochures provide more inside information. Also brochures collected at the Offshore Technology Congress held in Houston, Texas have been used to provide this paper more update of the available oil and gas technologies.

Article of scientific journals
Articles of scientific journals provided additional scientific information and knowledge. The scientific journals can be used as evidence but are difficult to access via internet. The most scientific journals related to offshore industry argue about geology and seismologic technology advances. New hydrocarbon processing equipment is mainly discussed in patent database.
Minutes and slides of meetings
During the research, participation at several meeting was very useful to gain insight into the MPP development and future subsea intervention projects that KCI will be involved in.

Annual reports
The annual reports of oil companies provide information of the new projects and future exploration area. The annual reports also give information about the expenditures, revenues and acreage.

Interviews
In order to combine so many sources as possible interviews were conducted to assess the SNM key processes, the MLP and TC theoretical concept. The interviews were carried out with people who worked on the Multiple Purpose Platform (MPP) projects in the past. In the interview the developmental phases, facilitating and hindering factors in the development, the goals and expectations of the important actors of the MPP project and the personal experiences with respect to knowledge accessibility and personal development throughout the project will be discussed. During a meeting with the general manager of KCI, the KCI employees that were engineers during the MPP project were selected. The persons interviewed are from different disciplines within KCI:

- Senior process engineer
- General manager
- Senior piping engineer
- Senior structural engineer
- Technical manager
- Piping project manager
- Junior process engineer
- Project manager

These persons were interviewed to obtain information about the MPP project. For the subsea case there was less people to select. The general manager and senior engineers have been in close contact with the clients that are interested in subsea intervention. However, the information that they provided was not sufficient for this research. In order to obtain more information about offshore industry and subsea development two persons from Technical university of Delft were interviewed.

In order to obtain information from the client side, an interview with a person who was present at the meeting with KCI was ideal. Nevertheless, since the name of the company changed from Clyde Petroleum bv into Wintershall bv, there is no one left who is acquainted with the MPP project.

Questionnaire
Questionnaire will be used to compare the answers of the respondents. The questionnaire is based on the niche development improvement criteria as described in section 2.6.6 and 2.6.7. The results of the questionnaire are given in Appendix A and B.

The major actors in this offshore regime are technology related. It should be noted that NGO’s and other non-technology related actors have insignificant influence on the niche development. During the research the articles and campaign of societal group have been studied and analyzed (see appendices H and K).
3. Niche analysis: CASE 1 Multi Purpose Platform

3.1 Introduction

In this section, the key processes will be described in a nutshell and in the following sections the quality of the key processes of the MPP niche development will be described. The answers of the interviewees are summarized in appendix A. The responses to the SNM related questions are graphically displayed in appendix C.

KCI is known for providing fit for purpose solutions as process hardware, structural designs (modular and light weight structures) and software based analysis. KCI provides clients operating in the marginal fields of the North sea fit for purpose solutions. Recovering hydrocarbon from marginal fields is an unconventional way of oil and gas recovery. For oil and gas recovery in these marginal fields custom-made alternative oil/gas recovery technologies should be applied. These fields are not exploited by the multinationals (i.e. Shell, BP, Total etc) because of the following reasons:

1. With the conventional oil recovery technology not enough hydrocarbon can be extracted to make profit.

2. The oil/gas resources are far from the existing infrastructure. It is in this case not profitable to invest in new pipelines or hydrocarbon carriers.

3. The oil/gas recovery could lead to environmental disasters. An example is the gas recovery in Groningen causing earthquakes and decrease of ground level.

4. It is difficult and expensive to extract hydrocarbon from tar sand, deep sea areas and remote areas (Arctic areas)

Thus operating in an unconventional way is considered a niche. In this chapter the SNM will be applied on the MPP niche development which was initiated by KCI and an oil company that owns several oil and gas fields in the North sea.

SNM was developed initially by Kemp et al., (1998), Rip & Kemp (1998), Hoogma (2000) and Hoogma et al., (2002) as a tool for nurturing promising technologies in transport to enhance the diffusion rate. By building a complementary institutional setting (societal needs) in which they can meet the societal needs. It should however be noted that in this research the SNM approach will not be used as a tool to find out why sustainable technologies still have unsuccessful market introductions. In this research the SNM approach will be used in a non-traditional manner. It is anticipated that not all SNM features can be used during the research as the society plays an insignificant role in this and incremental innovations require relatively less regime change compared to radical innovations.

First the technology will be defined and then the interaction between the social and technological aspects will take place. According to SNM technology is more than the machine designed by engineers or technical experts. The technology also embodies ideas and practical issues incorporated in the design to overcome as much as possible non-technical barriers that hinders the market introduction or application. The design of a technical expert is merely a prototype what needs further testing outside the technical environment to exclude paradigm or “locked in”. The way of problem-solving thinking of technical specialist will be confronted
with the way of thinking of the users, policymakers, financial institutions, legislators, design approval or even representatives of broader public like Greenpeace organization. After the way of thinking session (i.e. experiment phase) the expectation and vision of the new technology should be assessed. Because if the technology really solves a problem but when the expectation is low or the vision is way different, the technology will not be introduced successfully. Perhaps it will be tried once or twice just out of curiosity but not taken seriously. After these two steps, the technology is improved and introduced to strong network of actors willing to:

- test,
- invest in the technology,
- buy and use the technology,
- buy the knowledge to use the patented technology

The environment in which the technology will be introduced fits better to welcome the technology. The diffusion process will be improved because the technological options are evaluated at several important angles. A multilateral decision will make the introduction process much easier and comprehensive for parties close and far from the technological process. This is very important because during the testing period (learning process) these non technical factors can jeopardize the development of a certain technology or technical innovation.

### 3.2 Multi purpose platform

The MPP concept is development and patented by KCI. The platform is a self-elevating and self-installing platform, which is an innovative alternative to conventional platforms. The design is generally suitable for water depths in the range of 15 to 40 meters. The deck main dimensions are typical 35 m length x 25 m width and 7 m depth. The hull can be used as storage tank (e.g. diesel tank, potable water tank etc. etc.). The length of the platform will be chosen so that the movable crane mounted on the top deck, at the far opposite corner of the helideck, would just be outside the obstacle free zone required for safe landing of a helicopter in accordance with the CAP 437.

![Figure 3.2 Self installable platform designed by KCI](http://www.kcibv.nl/products/self-installable-platforms.jx)
During installation the complete deck is self-elevating on a purpose built jacking system (or strand jacks commercially available) supported by the four tubular columns with a radius of 1.2 m. At the mud line the support columns frame into suction anchors, which embed into the seabed. After jacking the deck into its final position, the deck is welded to the legs for vertical fixation and clamped on the circumference for rotation fixation after which the jacking system is removed using the movable crane. Once removal has been completed, the crane will be fixed in a position suitable for well workover and barge loading. Similar cranes have been installed on the previously built self installable platforms.

Table 3.2: Example of a concept features small size self-installable platform

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water depth</td>
<td>30.3 m</td>
</tr>
<tr>
<td>Number of well slots</td>
<td>2-4 (conductor 32&quot;)</td>
</tr>
<tr>
<td>J-Tube</td>
<td>1 x 12” (for power cable) and 1 x 18” (for 6” pipeline)</td>
</tr>
<tr>
<td>Caissons</td>
<td>1 (Overboard water)</td>
</tr>
<tr>
<td>Helideck</td>
<td>Suitable for S-61 helicopter</td>
</tr>
<tr>
<td>Crane</td>
<td>Movable crane, capacity 8t at 8.0 m</td>
</tr>
<tr>
<td>Life boat</td>
<td>Davit launch lifeboat</td>
</tr>
<tr>
<td>Accommodation</td>
<td>Suitable for overnight stay of 8 persons</td>
</tr>
<tr>
<td>Foundation</td>
<td>Suction cans</td>
</tr>
</tbody>
</table>

The following sequence for transport and installation is used for the self-installable platform:

1. Install transport and installation aids on deck of platform;
2. Connect tugboats (towing lines);
3. Perform ROV bottom survey;
4. Move platform into position by means of the tugboats;
5. Start lowering the deck legs;
6. Jack up platform 2 m clear of surface;
7. Release towing lines;
8. Jack up platform to operating level;
9. Fasten leg wedges and weld leg fixing plates;
10. Removal installation aids;
11. Platform completion (commissioning)

The MPP which is certified Lloyds Register as a self-installing fixed platform, provides the clients with many significant cost effective benefits in comparison with the conventional platforms that include:

1. It eliminates the need for clients to invest in expensive jacking systems by renting out systems, installation and decommissioning of conventional platforms;
2. No return to port prior to re-commissioning is required;
3. Weight reduction achieved by means of the catamaran-shaped 1,600 m², 400 tons capacity deck;
4. Round legs structure enhances economic design and ensures low drag;
5. Storage facilities available in the hull of the structure.

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30 P and Q block development feasibility report chevron KCI. April 2007
31 P and Q block development feasibility report chevron KCI. May 2007
3.3 SNM approach applied on the MPP case

A niche can be assessed by analyzing the key processes of SNM as described in section 2.2. The MPP has been assessed in order to find out the characteristics of an offshore industry related final product (i.e. process hardware). These characteristics are identified and analyzed in this chapter. The SNM approach describes three dynamic processes that can influence a product during the experimental and niche development phase:

- Expectations
- Actor-network
- Learning curve

These processes will be used to explain the success or failure of an experiment or market introduction as described in the success criteria. The marginal field niche developments are analyzed by using personal interviews and observations. The hypothesis that will be used is: A good quality of key processes is required to achieve a successful market introduction. When the quality is poor the new technology will not be widely accepted by the client and society. With the help of the KPQI criteria (see section 2.6.6) the following questions will be answered:

Was the expectation shared amongst the actors?
Which actors participate in the niche development?
What did the actors learn during the project?
What is the quality of the three key processes?

3.4 Expectations

The articulation of expectation and visions provide directions to the learning process and niche development. Expectations are related to the promises of the new technology. The promises of the technology are powerful when they are shared, credible, specific and coupled with the clients and certain society needs. Powerful promises should be translated to other actors in the actors-network. Furthermore, activities need to be developed to maintain the expectation shared amongst the actors.

In order to obtain the required information about the qualities of the SNM key processes, the MPP niche development 6 persons of different KCI disciplines (Structural-, Process-, Piping- and Management department) who were working on the design of the MPP were interviewed. In Appendix A the result of the interviews and queries can be depicted. Not all information was easy to be obtained because the MPP project took place 9 years ago. However, access to information (i.e. user-friendly archive system) about this project was not a problem. In the following sections the answers to questions related to the performed ex-post analysis (three niche key processes) will be described.

The information about expectation was obtained by means of survey, interviews and project information from minutes of meeting.

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The research findings
According to the persons interviewed (i.e. piping engineer, process engineer and general and technical manager) the expectation was coupled (see question code VE.1, SP.2 and SP.3).

The shared expectation can be articulated as:
Best solution for exploiting marginal fields in shallow waters of the North Sea because of the significant cost effective benefits described in section 3.2.

There was no explanation for this shared expectation but everyone knew what to do. Everyone argued that from the start the client, the financial actors who approved this project and KCI believed in the advantages of the MPP concept (see question code SP.4).

The former general manager of KCI always managed to keep the engineers focused on the project. According to the engineers that were interviewed, testing of models supported the credibility. During the niche development, no societal influence on the technology was expected to slow down the development process. There were no incentives to stop with exploration and exploitation of marginal oil and gas fields in the North Sea. This grew the confidence in this promising technology. According to the engineering everyone knew that the MPP offers more advantages than the conventional fixed platforms. The new concept was not a threat to the fixed platforms but extended the production years of the existing conventional platforms. Because of the fact that it was no threat, this MPP innovation is considered as an incremental innovation.

The MPP was perceived as a pre-processing platform that has equipment on board that extracts hydrocarbons from the wells and transfers it via compressors, shipping pumps and pipelines to an existing full equipped conventional platform. The need for not extracting from a small well by another conventional platform disappeared by the introduction of the MPP. After the well was empty, the self installable platform could be towed to the other well in the area. KCI also managed to patent the MPP which also substantiate the expectations. The most engineers thought (and still think) that in the future more MPP’s should be built but there are still some technical limitations and some shortcomings. The engineers have also acknowledged that non-technical facets should be included as soon as possible to avoid scope changes and setbacks during the further development of this MPP which is still a technological niche(see question code PO.3). Technical improvement is an indicator for progress. Therefore, testing of models and prototypes were the way to monitor the improvement and that also substantiate the expectation.

KCI has achieved this shared expectation by organizing progress meetings on a regular basis, testing of its prototypes and constantly adjusting its products to the need of the client.
3.5 **Actors-network during MPP niche development**

An actor-network should be broad to have sufficient resources and financial resources. The quality of this key process should be good. The learning processes and coupling of expectation takes place within the actors-networks. The information of the actors-network is obtained by means of survey, interviews and project information from minutes of meeting (see Appendix A).

**The research findings**

According to the general manager the actors-network consisted of heterogeneous group of actors (see question code AN.1). The actors-network composition (see Figure 3.5) consisted in the beginning of KCI and Clyde Petroleum and gradually actors entered the network. This gradual process of adding network is a way to find the actors that will share the expectations with the original actors-network (financial institutions, oil companies and engineering and construction companies). It is very important to work together with fabricators and supplier that have sufficient experience with conventional platforms. According to Weber et al (1999) experienced actors is a crucial factor. The interaction between actors was very important for the achievement of fully accepted high quality process hardware that consisted of a structure, top-side and the process equipment to process the natural gas. The general manager also said that agreements were made to assure commitment of the actors throughout the MPP project (see question code AN.2). According to Weber et al (1999) procedures to assure long term commitment is very important in the key process of alignment of actors. There were also procedures in terms of contracts and terms and conditions documentation available to prevent actors from pulling out of the project without juridical consequences.

KCI also took into account that the composition of the actors-network will change during the project. The general and the technical manager did contact companies (actively creating niche and finding supporting actors) operating in the marginal fields that desire minimum facilities topside. Presentation and demonstration were held at those companies in order to explain the advantages of the MPP concept.

Information about the actors-network is obtained by the survey and interviews (see appendix A and C) held at KCI and project documentation available at KCI. The actors-network during the MPP niche development included (see Appendix A; question number 1):

1. Users
2. Fabricators and suppliers
3. Government and policy makers
4. Research and development
5. Financial institutes
1. User

**Clyde Petroleum Exploratie BV**
Nowadays the company name is Wintershall Noordzee BV\(^3\). Clyde petroleum exploratie bv was the client that gave KCI order to design a Multipurpose platform for exploiting its marginal natural gas fields in the North Sea. KCI was the client representative during the detailed engineering, procurement and installation. KCI has handed over the MPP after commissioning.

2. Fabricators and suppliers

The following companies provided equipment and structures:

**RLD**
This company provided the helicopter deck design. Helideck will be used by helicopter transportation of personnel from and to the platform. Close liaisons with KCI is required to assure that for example the vent stack is not an obstacle in the flying route of a helicopter. Thus, during the niche development the regulations related to helicopter should be taken into account.

**IHC**
The company was formerly known as IHC Caland N.V. has changed its name to SBM offshore bv\(^3\) has been the supplier of the jacking system. The platform is self-elevating type. A jacking system is therefore required to lift or lower the four tubular. A good communication and learning process is required as the jacking system is one of the vital parts of the MPP.

**Hollandia**
Hollandia bv\(^3\) is a shipyard where construction of the structure and top-site took place. The structure and top-side were built at Hollandia bv and transported via the Maas river to the North sea where the installation took place. The structure is significantly lighter than the conventional platform structure. Moreover, more weight can be carried per square meter due to the innovation and calculation conducted with specialized software.

**Genius VOS**
Genius Vos bv\(^3\) provided the pipe lay analysis and pipeline on the seabed to connect the new marginal field to the platform and to the existing pipeline. In 2005 GTI/Suez and Vos groep issued a letter of intent about the takeover of the Genius Vos company. Since then GTI is the market leader in maintenance of offshore sites.

**HOC**
HOC BV\(^3\) is consultants to Clyde Petroleum Exploratie BV for all Marine Aspects. In the year 1996, this company was responsible for the installation of 3 Multiple Purpose Platforms (MPP). The removal and re-installation of a Multiple Purpose Platform (MPP) from

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\(^3\) [http://www.wintershall.com/home.html?L=4](http://www.wintershall.com/home.html?L=4)
\(^3\) [http://www.sbmoffshore.com](http://www.sbmoffshore.com)
\(^3\) [http://www.hollandia.s3c.nl/](http://www.hollandia.s3c.nl/)
\(^3\) [http://www.gti-group.com/nl/nieuws/overnamegtioilandgas](http://www.gti-group.com/nl/nieuws/overnamegtioilandgas)
\(^3\) [http://www.hocbv.nl/clyde.htm](http://www.hocbv.nl/clyde.htm)
location P2-SE to location P6-D was performed successfully 4 years later in 2000. The installation of Multiple Purpose Platforms always took place in co-operation with KCI.

**SPT**
SPT BV[38] Offshore is the world leading offshore contractor specialized in the design, fabrication and installation of suction pile foundations / anchors (cluster pile and SEA) and Self Installing Platforms (SIPs) for the offshore industry. The support columns are framed into suction anchors provided by SPT. The suction anchors are embedded into the seabed to avoid the platform from drifting away.

**3. Semi governmental organisations and policy makers**

**Lloyds**
Lloyds did the inspection on site and is responsible for the permits. According to the European directives, a notified body (NOBO) should inspect an installation before commissioning and kick off.

**4. Research and development and Engineering**

**Marin**
Marin (Maritime Research Institute Netherlands)[39] was responsible for model testing and research. MARIN is also known for carrying out installation monitoring projects. This indicates that a well experienced company has joined the actors-network during the model testing (experiment phase).

**KCI**
The design, pre-engineering, procurement, detailed engineering, construction and installation of the MPP were done under supervision of KCI management. KCI was thus the client representative throughout the project. The actors-network formation was initiated and aligned by KCI.

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[38] http://www.suctionpile.com/
5. Financial institution

Financial institutions within the actor network are credit institutions, money market funds and banks. It is not possible to trace how funds were raised to finance this MPP project. After justification and approval of a project, financial institution will provide the oil companies the requested amount of money (i.e. loan) to pay the engineering and installation of the subsea processing systems. Financial institutions are more likely to invest in SPS when the technology is proven. The Roace\textsuperscript{40}, proven reserves in the well and return on investment are also two important tools that the financial institution use in order to estimate the risk of the project which embeds the new technology. The main driver for the investment in new technologies as SPS is the high oil prices. Oil companies are offering investment companies participation in oil and gas projects. The 8 typical steps in an oil and gas projects includes:

1. Geological research
2. Mineral rights
3. Financial partners
4. Drilling work on the field
5. Production
6. Sale of oil and gas
7. Economical statement
8. Pay out

The return in investment is paid out on a quarterly basis while oil and gas is produced and sold. Typical demands of investment companies\textsuperscript{41} are:

- Oil companies should invest in their own project on a typical minimum basis of 20%;
- The project must be profitable also on low oil and gas prices;
- Minimum projection should be at least 17% internal rate of return;
- Minimum project horizon of 10 years.

6. Public organizations

The influence of the public organization was and is still minimal. According to the interviewees there were no significant societal groups that influenced the niche development of the MPP. Greenpeace for example launch protests against dumping in sea of platforms and environmental damages caused by oil companies. The MPP should be considered as a societal benefit because the MPP will be relocated after field depletion instead of dumped into the sea or dismantled on shore. Societal groups would be still worried about illegal dumping of fluids into the sea that affects the marine life. So far, there was no significant opposition from the NGO’s to be discovered during this research.

\textsuperscript{40} Osmundsen, P., Asche, F., Misund, B. and Mohn, K., (2005) Valuation of international oil companies-the RoACE era. Stavanger. University of Stavanger; CESifo (Center for Economic Studies and Info Institute for Economic Research)

\textsuperscript{41} http://www.fivecontinentgroup.no/Terra/introductionoilandgas.pdf
Figure 3.5 Actors-network map for MPP niche

The actors-network map is depicted in Figure 3.5. The arrows represent the interaction between the actors during the development of the MPP.

### 3.6 Learning processes

The knowledge and information transfer within the actor-network should also be of good quality because it keeps actors focused on the development of the new technology. Leading firms (major engineering consultancy, oil companies and major vendors) should supply knowledge, experience and know-how to small and medium firms (SME’s). The leading firms provide the finance while SME can provide more innovation momentum. Users, clients or customers should have incentives to learn about the new ideas embedded in the process hardware and learn how to use it. This can be stimulated by good communication and the involvement of future users during the innovation process. Users with experience and strong engineering pedigree also have influence on the learning curve of the new users. Users with experience and strong engineering pedigree also have influence on the learning curve of the new users. The learning curves have great influence on the successful market introduction and site acceptance of the MPP.
In this section basically the following two questions will be answered:

- What did the actors learn during the project?
- What is the quality of the learning processes?

KCI has used the knowledge of fixed platforms to develop a self-installable platform. KCI has also performed de-bottlenecking study in order to build a new generation MPP’s (see Appendix A-6; question code LP.1).

According to the KCI engineers and managers, the scope has been changed several times. It was not easy to design the self installable platform (MPP) at once. Some KCI engineers have worked previously for Overdick, a company that was developing another self installable platform. The knowledge was transferred from Overdick bv to KCI (see Appendix A-5; question number 5).

The design of MPP is derived from the existing fixed platforms situated in the North sea. KCI has developed the first generation MPP before the self installable platform of Overdick bv. After market introduction of the first generation MPP, a second generation MPP was built.

KCI also performed de-bottlenecking study for a MPP (i.e. P2NE). The results of the de-bottlenecking study are: no complex fabrication required, installation in deeper waters became possible and strengthened structure so it can yield more weight on the top-side (see Appendix A-4; question number 3).

However, the market introduction of both self installable platforms were successful there are less than 5 self installable platform in service. Two successful relocation of MPP’s (the platform moves from one field to another field within 48 hours) have taken place so far. It is proven twice that the MPP self installable concept works.

The management (see appendix A-6) is also aware of the fact that the MPP should be customized to meet the requirements of other potential users (client).

During the niche development institutions has been contacted to discuss the regulation framework. The regulation concerning demolishment of platform has been changed and at the time it looked if the regulatory change will benefit the MPP technological niche.

During the MPP design, the engineers and fabricators must take the following regulations into account:

1. Dutch legal and statutory requirements
2. European regulations (CE marked, PED regulations for High pressure equipment checked during inspection by Lloyds’ register)
3. International industry codes and standards (e.g. API, DIN, ASME, ASTM)

These rules are embedded in the new technology or process hardware. The product will not be accepted by the client when the new technology or process hardware don’t comply with the regulations and standards.
In order to provide insight in the MPP learning process, the bottlenecks and the solutions is given in the tables below.

Table 3.6.1. Technical Bottlenecks and solutions

<table>
<thead>
<tr>
<th>Bottleneck</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>Large distance required larger footprint due to additional equipment on topside</td>
</tr>
<tr>
<td></td>
<td>Make use of the pontoon as storage vessel is not always a practical solution</td>
</tr>
<tr>
<td>Technical limitation</td>
<td>Limited to water depth (no deep sea operation)</td>
</tr>
<tr>
<td></td>
<td>No solution</td>
</tr>
<tr>
<td>Installation</td>
<td>Complex fabrication and installation</td>
</tr>
<tr>
<td></td>
<td>Improved by the 2nd generation MPP</td>
</tr>
</tbody>
</table>

Table 3.6.2. Economical Bottlenecks and solutions

<table>
<thead>
<tr>
<th>Bottleneck</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding/investment</td>
<td>Cost estimates indicate that the CAPEX of subsea and monotor are identical</td>
</tr>
<tr>
<td></td>
<td>No solution</td>
</tr>
<tr>
<td>Pay off</td>
<td>High steel prices</td>
</tr>
<tr>
<td></td>
<td>No solution (high capex)</td>
</tr>
<tr>
<td>Demand</td>
<td>Decreased demand since subsea technology is improved</td>
</tr>
<tr>
<td></td>
<td>No solution</td>
</tr>
</tbody>
</table>

3.7 Conclusion

Starting from the early 1990's, Schot et al., (1994), Weber (1999), Hoogma (2000) and Kemp & Rotmans (2001) have studied the internal niche processes as described in this chapter to describe their findings of innovation research and socio-technical studies. The quality key processes of this SNM research will be described in this section. By taking into account the results of the investigation of the key processes using SNM (KPQI list), the following can be concluded:

Expectation

It can be concluded that the expectation was shared. Everyone believed in the advantages of the MPP. MPP was perceived as the best solution for exploitation of marginal fields in the shallow waters of North Sea because of the cost benefits and of the self installable feature. Compared to Brent Spar this platform can be removed and re-used at another field. Dumping into the sea or demolishing of a platform offshore will not be needed any more. Testing of models and patenting of the MPP concept supported the credibility during the niche development. The quality of the expectation was good however it is difficult to prove whether blind optimism was the driving force. This optimism may have caused that the stakeholders might have missed some social coupling.

Actors-network

As recommended by Weber (1999), Hoogma (2000) and others, the actors-network should consist of a heterogeneous group of experienced actors. This was also the case during the MPP niche development. The actors-network grew gradually and KCI chose to work with experienced companies and organizations. It was a mixture of SME's and big organizations. The expectation was shared and substantiated by testing of models. This was very important for the alignment of the actors within the network. KCI might have failed with introducing this MPP concept to sceptical actors. This is the reason that the actors-network did not expand enough to get widely accepted. Other companies have chosen for alternative options or the MPP look-a-likes launched by the competition (e.g. Overdick). The quality of the actors-network was good although for widely acceptance the network did not function well.
Learning process
When the expectation is of good quality and the actors are aligned, the learning process probably will be of good quality. According to Geels (2002) the key niche process reinforces each other. KCI has used the knowledge and knowhow of persons that where already involved in the development of self-installable platforms. The in-house experience with designing of fixed platform was also beneficial. After market launch of the first MPP’s, debottlenecking studies were performed in order to launch a second generation of MPP. The societal groups (e.g. Greenpeace) that protested heavily against the dumping of the Brent spar have indirectly encourage engineers to design self installable and re-usable platforms as sea disposal and demolishing of oil platforms met societal opposition. The adjustments that should take place during learning processes described in section 2.2.4. took place. The scope has changed several times because of limitations met during the design but not all interviewees agree with that statement. Adjustment due to production constraints also took place because less structure should be used. It was anticipated that inspection will be conducted by Lloyd’s register. Articulation of social environmental benefits besides high ROACE should be an incentive for the financial institutions to invest in this MPP project.

In the following chapter, the quality of the key processes of the subsea niche development will be described. The findings will also be discussed. The results of the regime analysis will be discussed in chapter 5.

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4. Niche analysis: CASE 2 subsea technology

4.1 Introduction

In this section the quality of the key processes of the subsea processing system niche processes will be analyzed. The answers of the interviewees are summarized in appendix B. The second case will be subjected to the SNM approach (three key processes). This is an ex-ante analysis of the global subsea niche development. It is also called frontier technology because it is time to develop is now. The subsea processing system technology is a market niche at the moment. The conventional platforms still have the biggest market share. First the technology will be explained and then the quality of key processes (i.e. coupling of expectation, actors-network and the learning process) will be discussed.

The global energy demand grows, so there is a need to speed up the development of oil and gas production related niches in order to get the most from deepwater, remote, and marginal Fields. The easily accessible oil is increasingly scarce. Subsea niche development is the most promising technology today. According to the report published by energy analyst Douglas-Westwood Ltd° and technology specialist OTM consulting, the subsea processing has the potential to reduce CAPEX on offshore platforms by placing much of the hardware required to separate hydrocarbon fluids on the seabed. Nowadays, platforms are only necessary when the oil/gas reservoir is far from the infrastructure (i.e. maximum facility platform or pipeline). The advantages of subsea equipment are°:

- not manned
- lower CAPEX (i.e. no structure is required)
- minimum equipment is required
- no limitation of surface or weight as on a platform

Oil and gas wells typically produce a well fluid that requires separation to remove formation water° from the flow stream coming out of the well. The separation typically takes place:

- on a production platform;
- via a minimum facility platform (e.g. MPP, unmanned single leg platform°) and transferred via pipelines to a production platform or
- on a vessel (e.g. FPSO).

This usually requires pumping the reservoir fluid, including the formation water, to the surface production facility. In deep water installations the energy required to pump the reservoir fluids is extensive.

A subsea processing system includes a separator for separating heavier (e.g. oil) and lighter components (e.g. gas) of well fluid flowing from a subsea well and transferring it to a surface processing facility for further processing. The formation water will be removed by a coalescing unit. This unit causes water droplets in the well fluid flowing through the tubes, to coalesce into larger droplets so it can be collected and processed further in a water treatment

° Subsea Processing Game changer Report 2006-2015, Douglas Westwood
° Presentation of KCI: gas and oil field development plan of Chevron.
° Water that occurs naturally within the pores of rock.
° http://www.offshore-mag.com/Articles/Article_Display.cfm?Article_ID=253275
unit. The underwater pipelines which are used to transport the reservoir fluids to an existing platform (because the existing platforms are connected to the infrastructure) are also a part of the subsea processing system.

4.2 Subsea processing systems

In general, the oil and gas industry faces increased pressure to reduce costs against a background of squeezed margins, limited resources, R & D budget cuts and new environmental concerns (see appendices H and K). Advances in subsea technology have created exciting new opportunities for the oil and gas industry to use subsea processing system to extract more hydrocarbons and to maximize well production efficiency.

The Subsea processing systems can realize the following:

1. Increase in reserves recovery;
2. Remote subsea wells connected via pipelines (i.e. tieback) to shore or host platforms;
3. A wider variety of oil and gas fields could be developed entirely subsea without platforms;
4. Gas fields in very deepwater or in harsh environments such as the Arctic (e.g. for example in Russia’s Shtokman project\(^{48}\); 550km offshore), could be tackled more economically.

The environment of a subsea separation unit and a unit on a platform differs because of the high hydrostatic forces imposed on the separation vessels lying on the seabed. The subsea vessels can be made stronger by increasing the size (thus also the weight). On the seabed there is no limitation of surface or weight as on a platform. Subsea processing systems encounter a common disadvantage, it is that once installed subsea, maintenance becomes difficult because of the sea depths. Further, shutting down a separation system for maintenance would normally require shutting off well flow, which is expensive. The subsea fabricators are still developing this technology to solve this problem.

Generally, greater water depths will require a higher wellhead pressure with corresponding lower actual gas volumes when separation takes place at the sea floor. Lower gas volumes are beneficial for oil/water separation because fewer gas bubbles will move vertically and disturb the horizontal flow pattern generated by the oil and water flowing through the separator vessel. The low gas percentage also allows more of the separator vessel to be utilized for oil/water separation. Thus, the introduction of subsea technology increases the hydrocarbon recovery and improves the flow assurance.

\(^{48}\) [http://www.offshore.no/admin/ewebeditpro2/upload/shtokman.jpg](http://www.offshore.no/admin/ewebeditpro2/upload/shtokman.jpg)
In order to obtain the required information about the subsea niche development 2 persons of the Technical university of Delft, Offshore technology faculty were interviewed (see appendix B). Thereby the technical manager and a process engineer were interviewed about the visit at J.P. Kenny\textsuperscript{50} in Aberdeen, Scotland. In Appendix B the results of the interviews and queries can be depicted.

In the following sections the quality of the key processes will be described.

\textsuperscript{50} http://www.jpkenny.com
### 4.3 Expectations

As described in the section 4.1, information was obtained by means of survey, interviews and project information from minutes of meeting. The oil price is driven by the increased world demand for energy (i.e. increasing need for transportation fuel\(^{51}\)) and political pressures\(^{52}\). Higher oil price triggers investment into remote area where subsea technology is required to exploit that field. Subsea technology introduced by MOC’s meets the need of the society by providing the society electricity, heating and fuel for vehicles. It also provides wealth to countries as for example Nigeria\(^{53} \, ^{54}\), Trinidad\(^ {55} \, ^{56}\), Brazil\(^ {57}\) and Indonesia\(^ {58} \, ^{59}\). New technologies as subsea processing systems contribute to the economies as an employer, a retailer and energy producer. The subsea processing systems are already proven technology. Major activities in West Africa with many big fields with a lot of subsea intervention are regarded as successful testing area of subsea equipment. The SPS was several years a small niche in the offshore petroleum industry, its evolution throughout last decades has attracted a lot of attention because they offer a means of producing field extremities not reachable by drilling from existing platforms. Moreover, they offer production options where field economics do not justify the installation of one or more additional platforms\(^ {60}\). Also according to the interviewee of TUD (see appendix B-1) all oil developments are advantaged by the higher $60 oil price. Remote fields, small fields and other fields regarded as uneconomic are now regarded as profitable fields (see appendix F).

KCI is gradually getting involved in the subsea completion projects. When a fixed platform or MPP installation is too expensive, subsea tie-back solutions\(^ {61}\) will be provide to the clients. High cost saving are offered by subsea tie-back solutions because it maintains the existing platform located at a depleted well in production (i.e. production extension) and no structure has to be built.

The Dutch company Heerema warns that there are not enough vessels for heavy transportation available to meet the increasing demand of subsea projects. This means that the marine actor has high expectations.

Over the period to 2015, at least $3.4 billion is likely to be spent on subsea processing systems, which in the most favourable conditions could increase to $5 billion\(^ {62}\). This forecast indicates that expectation is shared and the existing subsea equipment and projects are performing well.

According to the persons interviewed (i.e. general and technical manager of KCI) and interviewee of TUD (see appendix B-1) many National Oil Companies (NOC) are very optimistic. The expectations are coupled (i.e. good quality) because it is based on confidence

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\(^{52}\) [http://www.ibtimes.com/articles/20060515/oil-prices-qatar-oil-minister-abdullah-al-attiyah.htm]


\(^{54}\) [http://www.chevron.com/operations/Nigeria.aspx]

\(^{55}\) [http://www.businessweek.com/adsections/2006/pdf/100906_Trinidad.pdf]

\(^{56}\) [http://www.offshore-technology.com/projects/bombax/bombax3.html]


\(^{60}\) [http://www.spe.org/spe-app/spe/jpt/1999/08/frontiers_subsea_completions.htm]

\(^{61}\) Existing platform processes hydrocarbon fluids produced by subsea processing systems

of the engineers of the oil and gas industry. Theoretically, a good quality of coupling expectation depends of the credibility based on testing of prototypes or successful way of meeting societal and industry needs. The confidence of oil and gas industry is largely based upon the fact that over the decades the oil and gas industry has had success in finding way to solve problems. Challenges were met by introducing new technologies and establish new arrangements with governments 63.

Higher oil prices are reviving the UK's ailing service sector, according to the Offshore contractors’ Association. The Chairman Woodgroup Engineering 64 claimed that there had been a resurgence in commitment to the North Sea by the major oil companies, contractors, and SMEs. This, in turn, had boosted activity throughout the supply chain. Another positive factor was the emergence of independent operators, which have proven more open to outsourcing field operations than their major counterparts 65.

4.4 Actors-network during subsea niche development

In this section, the role of the actors involved in the SPS niche development will be described. Thereby, it will be investigated what other actors expect from the subsea technology. As described in 2.2.3 the actors-network should be aligned. The learning processes and sharing of expectations takes places within the actors-network.

The findings of the research

According to the interviewee from Technical university of Delft (see appendix B-1; question number 10) the global actors-network involved in the niche development and market introduction of subsea equipment consists of the following major players. The global actors-network of the subsea market niche development includes:

1. Users
2. Fabricators and suppliers
3. Financial institutes
4. Government and policy makers
5. Engineering and R&D
6. Environmental groups

63 http://www.worldenergysource.com/articles/pdf/longwell_WE_v5n3.pdf
64 Bill Edgar is the Chairman and Chief Executive of Wood Group Engineering; Aberdeen.
1. Users

The users are the oil companies that use the SPS technology to extract hydrocarbon from their oil/gas wells. The major users are the national oil companies (NOC) and multinationals. The major players are:

- BP,
- Shell,
- Total,
- Chevron Texaco,
- Statoil
- Hydro.

Major oil companies are collaborating seriously with suppliers to develop subsea processing. Examples include the seafloor processing collaboration of BP, ChevronTexaco, ABB and Aker Kværner, the Shell-Alpha Thames cooperation, and the Petrobras initiative. Shell is leading the industry in the development and installation of novel ultra deep production pipes and risers.

2. Fabricators and suppliers

The fabricators and suppliers design and build subsea equipment for clients all over the world. They are specialized in manned and unmanned subsea work systems, fabrication services and equipment for key international marine industries. There are several projects related to subsea processing systems. On the website of Subsea oil & gas directory ongoing projects can be found. In this case four typical fabricators and suppliers will be described.

**FMC Kongsberg Subsea**

FMC Technologies is the world’s leading supplier of subsea HPHT solutions. High-Pressure, High-Temperature (HPHT) subsea completion systems are the most technically advanced oil and gas solutions in the world. Two of the company’s largest customers, BP and Shell, have successfully deployed this new technology in the Gulf of Mexico.

**Well Processing**

Well Processing is a provider of engineering solutions for subsea processing. This company engineers for example water treatment modules.

**Scan Tech**

Scan Tech UK supplies subsea equipment and excavation services (e.g. subsea hydraulic and pneumatic diver and remote operating vehicles). The inventory of equipment includes: High pressure compressors, Low pressure compressors, High volume compressors, Steam

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67 and http://www.offshore-mag.com/display_article/
68 Subsea Processing Game changer Report 2006-2015, Douglas Westwood
69 http://www.shell.com/home/content/technology-en/developing_and-producing/deep_water/deep_water_production_12012007.html
70 http://www.subsea.org/projects/index.html
71 http://www.fmckongsbergsubsea.com
72 http://www.wellprocessing.com
generators, HP Wash down Units, Hydraulic power packs, Umbilical & cable reels, Hydraulic diver & ROV tools, Winches, Cranes, Hot air fans, A-Frames and bespoke equipment.

**JP Kenny**

JP Kenny[^72] has rapidly won a reputation for innovative subsea pipeline design for the North Sea. However JP Kenny is a worldwide group that offers a complete package of professional services for the execution of offshore and onshore oil and gas transportation, distribution and development projects. For example it has delivered subsea projects in all geographical regions (e.g. West Africa, Gulf of Mexico and Indonesia), and has participated in approximately half of the world’s subsea developments installed so far.

### 3. Financial institutions

Financial institutions are banks and other investors. The subsea technology would be considered and evaluated based on the ability to enhance the Net Present Value of marginal and small fields. The expectation should be shared with the financial institutions for approval of a project or investment in the field development. As described in over the period to 2015, at least $3.4 billion is likely to be spent on subsea processing systems, which in the most favourable conditions could increase to $5 billion[^73]. It seems that the financial institutions are willing to invest in this new technology.

### 4. Governmental institution

For many decades oil companies managed to rearrange agreements with national governments with respect to environmental issues and political decisions[^74]. Oil companies are also well-known for high lobbying expenses[^75]. ExxonMobil is an industry leader in both political campaign contributions and lobbying expenditures[^76]. Furthermore, according to Appendix B-1, subsea activities are well supported by the governments. In the UK, the organization UK Subsea[^77] is supported by the government. Government support is very important for the development of a market niche.

### 5. Engineering and R & D

Research is done by engineering companies (e.g. KCI), MOC, NOC’s and SME’s that provide subsea related equipment or solutions. The growing energy demand and the need for developing subsea processing system are the incentives for the engineering and research companies to invest or get funding for their research. The engineering companies will provide oil companies interested in SPS custom made solutions.

### 6. Environmental NGO's

Environmental groups are very concerned with the deep sea habitats as the offshore industry moves into the area searching for more hydrocarbon. The international marine legislation was created before many economic opportunities in the deep sea were feasible. This has resulted

[^72]: http://www.jpenny.com
[^74]: http://www.worldenergysource.com/articles/pdf/longwell_WE_v5n3.pdf
[^75]: http://www.sunlightfoundation.com/node/460
[^76]: http://www.exxposexxon.org/ExxonMobil_politics.html
[^77]: http://www.subseauk.org/
in a grey area for the environmental groups and the industry. According to the environmental groups the management and legislation should be improved so that the conservation of the deep sea environment can be balanced with economic development. The environmental impacts of subsea activities are not fully known. Thus, further scientific knowledge of the deep sea is required\(^\text{78}\).

Nevertheless, the use of inhibitors (e.g. methanol or glycol) will be reduced because water separation takes place on the seabed and not on a platform by reduced pressure conditions. For this specific discharge of chemicals which is a big environmental issue, the subsea processing has a positive effect\(^\text{79}\).

Figure 4.4 Actors-network map for SPS niche

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\(^{78}\) *New industries in the deep sea* Parliamentary Office of Science and Technology (POST), July 2007

4.5 Learning processes

The learning process is the third key process that should have good quality to achieve successful market introduction. In this section the progress made during the learning process will be discussed.

The niche has been development already. However, the subsea intervention was too expensive at that time or met technical constraints. Since the high oil price many remote big fields are being exploited with subsea equipment.

The engineers (see appendix B-1; question number 8) have learned about the subsea technology because of the major activities in West Africa. The Dalia field has more than 60 subsea wells. The subsea technology is still making progress.

Shell has made successful exploration and production of oil at depths below 2,000 meters with achieving the 2,300-meters depth record in 2004 (see appendix D).

Shell has also created a new generation of semi-submersible rig and subsea completion system and is also using remotely operated vehicles to conduct heavy and exacting work on the seabed.

The ROV (remote operated vehicle) is well developed and the AUV is emerging (see appendix B-1; question number 11). AUVs have the potential to broaden knowledge about many areas of underwater operations. AUVs are beginning to show their abilities as cost-effective tools in applications ranging from deepwater survey for the offshore oil and gas industry to military operations. The growing need for many facets of ocean observation also offers great potential for AUVs not only to enhance the performance of conventional ship-based operations, but also to operate in difficult-to-access areas such as below the arctic ice. Future offshore regions can thus be explored.

In the figure below the established, emerging and the future offshore regions are depicted. The increase of subsea arenas is an indicator for the improvement the subsea technology via learning process.

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On international conferences and exhibitions sharing of bright ideas and experiences take place. An example of this the 19th annual Deep Offshore Technology International Conference & Exhibition (DOT) held in Stavanger Norway on the 10-12 October 2007. Also OTC offshore technology conference is a big platform where new technologies less than 2 years will be demonstrated. The new technology should be proven (i.e. full scale application or successful tested prototype), have broad interest and significant impact. The new technology should change the way of doing things. Learning by doing can thus be demonstrated on the conferences.

According to the risk assessment conducted by DNV the personal risk exposure will be reduced by moving process equipment to the seabed.

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81 Arneberg, J. (2006), Delivering the frontier case of field solutions; Oil and gas innovation in the fossil fuel future, European seminar and dialogue, Brussels
82 http://dot07.events.pennnet.com/fl/index.cfm
4.6 Discussion about the use of the SNM approach

The SNM has been applied on both cases (i.e. MPP and SPS). The SNM approach is normally used to find out how potential radical innovations can be introduced successfully into the existing dominant regime (or existing market). The research based on SNM could also provide information about optimization of the dominant regime or transformation of the dominant regime. In this research, the SNM is used as tool to understand the technological developments of new technologies as MPP and SPS. Furthermore, SNM can also be used as policy tool. Therefore, the regulations with respect to offshore industry have been assessed to find out whether it supported the MPP and SPS niche development. The other reason why SNM is used in this research is that according to Kemp et al. (1998) the aim of protected spaces for development of promising technologies (i.e. radical and incremental innovations) is to learning about the desirability of the new technology, enhancing further development and the rate of application of the new technology.

In both cases KCI and other companies involved in the development of MPP and SPS learned about the desirability and at a certain time space enhanced the rate of application. However, it should be noted that during the research the society needs have a low impact. The reason for this is because the new technologies are not radical. In this research, the national governments are considered as the society and not the consumers. The national governments can apply tools to create a niche market and support a niche development by means of taxes, subsidies, permits as discussed in the previous sections. According to Schot et al (1996) the three key processes (i.e. expectation coupling, actors-network and learning processes) are very important for the niche development. These key processes have also been studied in the previous chapters. The SNM can also be used because it is anticipated that the development of the MPP and SPS are initiated when the expectation is shared among the actors involved in the experiment phase. The actors-network will grow and the resources will also increase. From the results of the demonstration projects or market niche the learning processes will generate new rules and new knowledge to further enhance the MPP or SPS.
4.7 Conclusion

In this chapter as in the previous the niche analysis is conducted in order to find out whether good quality of key niche processes (coupling of expectations, actors network and learning processes) determine the diffusion of subsea processing system (SPS). In general, it can be concluded that the successful diffusion of the SPS can be explained by the good quality of key processes. However it should be noted that the market introduction took place more than 30 years ago (see appendix E). By taking into account the results of the investigation of the key processes using SNM (KPQI list), the following can be concluded:

Expectation
The quality is good because the expectation is shared, credible, proven by successes in the Gulf of Mexico and West Africa. High oil price and increasing of energy demand (China and India) have increasingly substantiated the expectation.

Actors-network
The actors-network is very heterogeneous. The MOC’s are working together globally on different projects related to subsea technology. Examples include the seafloor processing collaboration of BP, ChevronTexaco, ABB and Aker Kvaerner, the Shell-Alpha Thames cooperation, and the Petrobras initiative. Shell is leading the industry in the development and installation of novel ultra deep production pipes and risers.

Learning process
The technological niche was initiated 30 years ago (see appendix E). The learning process is stimulated by the successful achievements throughout the years. Demonstrations, conferences, exhibitions, oil journals and internet websites contributed throughout the decades to spreading and broaden of the knowledge. The coast of West Africa can be considered as the test-bed of this growing market niche. Nowadays, the ROVs and AUVs are cost-effective tools in applications for deepwater survey and installation of equipment for the offshore oil and gas industry.

In chapter 3 and 4 the quality of the three key processes has been assessed. In the following chapter other factors (i.e. wider concept) that can influence the diffusion of a promising/new technology will be assessed. The interaction between niche and regimes/society will be assessed using the Multi Level Perspective (MLP) as described in section 2.3.1.

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83 Subsea Processing Game changer Report 2006-2015, Douglas Westwood
84 http://www.shell.com/home/content/technology-en/developing_and Producing/deep_water/deep_water_production_12012007.html
5. Existing regime analysis

5.1 Introduction

In reference to chapter 3 and 4 the niche analysis is conducted in order to find out whether good quality of key niche processes (i.e. coupling of expectations, actors network and learning processes) determine the diffusion of Multi purpose platforms (MPP) and subsea processing systems (SPS). According to Geels and Kemp (2000) a technology also needs to be supported by legislation and infrastructure. It is anticipated that promising technologies may also require changes in behaviour of the user and have major cultural impacts. In this case the MPP neither the SPS have cultural impacts or require changes in behaviour (i.e. regime optimization). These technologies are not radical as for example electrical vehicles. In this chapter the research will focus upon the existing legislation, the infrastructure and Dutch- and global oil industry trends.

The typical oil and gas production process will be described in section 5.2 and 5.3. The trend of the Dutch oil regime will be described in section 5.4. The Dutch continental plate has reached its oil peak in 1990. Since then the oil production has been declining. At the moment small and matured fields are being exploited. These fields which are known as marginal fields need creative oil and gas engineers to be exploited but also a high oil price. The marginal fields need process hardware as MPP, minimum facility platforms, subsea wells connected to existing processing platform and subsea processing systems. This will be discussed in section 5.5. KCI is involved in many marginal fields projects in the North sea. This will be discussed briefly in section 5.6. In section 5.7 the global trend and peak oil debate MOC’s and environmental groups will be discussed followed by the trend of major oil companies in section 5.8. In section 5.9 the conclusions will be drawn.
5.2 Oil production facility

The processing on board of an offshore central production platform should be described. There will be no description in this section about oil and gas explorations, drilling and platform demolishing & refurbishment. The type of production installation and platform depends of the amount of GIP\textsuperscript{85} and the composition of the hydrocarbons in the well. After these parameters are known a well and a platform designed, engineered and installed.

In case a offshore platform should process oil coming out of a oil well, provisions should be made to transfer ready to refine oil to ship, FPSO and via pipeline to shore. The oil production process on the oil production platform basically consists of:

1. Oil, produced liquids and gas separation
2. Oil and produced liquids separation
3. Produced liquid and oil separator
4. Desalination of oil
5. Produced liquids treatment
6. Pumps

![Oil production scheme](image_url)

Figure 5.2 Oil production scheme

\textsuperscript{85} Gas in place is the volume of hydrocarbon located in the well in BCM billion cubic meters

80
5.2.1 Process description of oil production

In this section the process phases will be discussed in order to understand the activities on a central oil production platform. The oil production process includes:

1. producing oil using the gas lifting technology or natural well pressure;
2. oil treatment so it can be transferred;
3. Transferring oil through the plant and to the pipeline or ship by using oil pumps.

Oil production
Oil will flow out of the well depending on the reservoir pressure and the oil density. When the reservoir pressure is not high enough, oil should be pumped by using electrical submersible pumps out of the well or gas lift technology should be applied. Gas or water lifting technology includes gas or water injection into the well. The oil density will decrease through the “bubbles formation” in the oil and it will flow again because it is relatively lighter.

Oil, gas and produced liquids separation
The first separation step is the separation of oil, gas and produced liquids. De-emulsifier should be used to stimulate the separation in the separator by using gravity. Desalination and Stabilization takes place on shore.

Gas recovery
The produced gas can be pre-treated and used for the following options:

1. Gas injection or gas lifting
2. Generate electricity
3. Injected into Gasunie pipeline

When the amount of gas is too high it will be flared or vented.

Water recovery
The produced water will be treated in oil water skimmers unit to remove all contaminants. The clean water can be used to re-inject into the well to maintain pressure or dumped into the sea via caissons.
5.3 Gas production facility

In case there is only gas, condensate\(^{86}\) and water expected to come out of the well, gas production facilities will be installed on the platform. The gas production facilities should provide gas that can easily stored in a ship or transported by using compression via pipelines to shore. The gas production facilities in the North sea basically consist of:

1. Gas and Liquid separation
2. Gas drying facility (TEG contact tower)
3. Hydrate inhibitor
4. Compression unit
5. LTS (Low Temperature Separation)
6. Condensate and produced water treatment
7. CO\(_2\) and H\(_2\)S separation (optional)

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\(^{86}\) Condensate is oily water that have a density of ca. 600 kg/m\(^3\)
5.3.1 Process description of gas production

In fig. 5.3, the gas production can be depicted. In this section the process phases will be discussed in order to understand the activities on a central gas production platform.

**Hydrate inhibitor**
Hydrate inhibitor (MEG\(^{87}\) or Methanol) should be injected to provide hydrate formation in the lines and equipment. The required amount of MEG or Methanol that should be injected upstream depends on the process conditions (i.e. operating temperature and pressure). The MEG will be collected together with the water phase in the gas/liquid separator. However, methanol should be separated from the produced liquid by using a methanol recovery unit.

**Gas and liquid separation**
Gas and liquid separation takes place by lowering the pressure and temperature (Joule-Thompson effect) by using a choke valve. The gas will be transferred to the fuel gas system where it will be dried and heated to avoid condensate in the compression unit. The liquids

**Gas compression**
In order to transfer the produced gas to the pipeline, the gas should meet the required process conditions of the pipeline. The compressors should be used to deliver the gas at the operating pressure of the pipelines. The compressors can be used to compensate the pressure drop over the pipeline as well.

**Gas dehydration**
The produced gas should meet the required operating process conditions of the pipeline. The wet gas should be dehydrated in a TEG\(^{88}\) contactor before entering the gas metering skid and pipeline. To ensure continuous production a TEG regeneration skid should be installed to remove all water from the TEG. Hereby, the TEG can be re-circulated continuously.

**Water and condensate treatment**
It is not allowed to dump produced liquids into the seawater. Therefore, produced liquids should be treated to remove the contaminated hazardous material. In some cases decontaminated water is injected into the pipeline and separated on shore.

**CO\(_2\) and H\(_2\)S treatment**
When the molecular weight percentage of CO\(_2\) is high, the corrosion rate in the pipeline will be above the maximum corrosion allowance\(^{89}\) of 3 mm. In this case CO\(_2\) should be removed. The H\(_2\)S treatment is required to avoid H\(_2\)S emission.

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\(^{87}\) MEG is methyl ethyl glycol  
\(^{88}\) TEG is Triethylene glycol  
\(^{89}\) The corrosion rate depends of the operating pressure and temperature.
5.3.2 Conventional production platform

On the Dutch Continental Plate (DCP) the supports of the platform are made of steel (i.e. hollow pipes). The steel construction is fastened by suction anchors to the sea bottom. The platform typically facilitates the following:

- Process hardware
- Utilities
- Power system
- Helicopter deck
- Accommodation for personnel

The platform can be surrounded by wells and satellites. A Satellite platform is a minimum facility platform where the wells are connected to the central processing platform via pipelines. On the satellite platform there is only space for jack-up rig\(^\text{90}\), maintenance rooms and drilling installation. A satellite on the sea bottom is called a sub sea well. The other platforms for deeper water are depicted in the Figure 5.3.2.

![Figure 5.3.2 Other type of Platforms](http://www.naturalgas.org/images/offshore_drill_platform.gif)

In the following section the oil regime will be analyzed. Literature research has been used to gather the required information.

\(^{90}\) self elevating working platform
5.4 Oil regime in the Netherlands

There is hardly any oil to be found in the Netherlands. The Netherlands produced in 2005 about 1.83 million Sm$^3$ (i.e. 1 m$^3$ dry gas at 15°C en 1013 mbar) oil of which 0.34 million m$^3$ from the North sea and 1.49 million m$^3$ onshore oil production plants. The oil production on the Dutch continental plate (DCP) decreased with 28% (comparing to 2004). The Netherlands produced in that year approximately 5000 Sm$^3$ per day which is about 31 450 barrels$^{91}$ per day.

On the contrary in Groningen the Netherlands possesses one of the biggest natural gas resources. The Dutch government decided after realizing during the first oil crisis in 1973 the risks and vulnerability of a large energy import dependency that the Groningen gas field should be conserved as much as possible for the future use and that the priority is given to the development of other smaller gas fields that were already discovered in the Dutch onshore an in the Dutch sector of the North sea. This policy is the Small Field Policy (SFP), and is investigated by Correlje (2004)$^{92}$.

The Netherlands produced in 2005 about 73 billion Sm$^3$ natural gas of which 25 billion m$^3$ from the North sea and 48 billion m$^3$ onshore gas production plants. The natural gas production on the DCP decreased with 16% (comparing to 2004). In the tables below the information about the Dutch oil and gas production is summarized.

Table 5.4.1 Oil and gas production in the Netherlands 2000 - 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Drilling</th>
<th>Gross Natural gas Production (x 10$^9$ m$^3$)</th>
<th>Gross Oil production (x 10$^6$ m$^3$)</th>
<th>Natural gas reserves (x 10$^9$ m$^3$)</th>
<th>Oil reserves (x 10$^6$ m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>30</td>
<td>67.80</td>
<td>1.55</td>
<td>1836</td>
<td>32</td>
</tr>
<tr>
<td>2001</td>
<td>40</td>
<td>72.26</td>
<td>1.63</td>
<td>1738</td>
<td>28</td>
</tr>
<tr>
<td>2003</td>
<td>34</td>
<td>68.70</td>
<td>2.47</td>
<td>1689</td>
<td>28</td>
</tr>
<tr>
<td>2004</td>
<td>21</td>
<td>77.50</td>
<td>2.46</td>
<td>1572</td>
<td>34</td>
</tr>
<tr>
<td>2005</td>
<td>19</td>
<td>73.00</td>
<td>1.83</td>
<td>1510</td>
<td>36</td>
</tr>
</tbody>
</table>

In the Netherlands there are more employees indirectly involved than directly involved in the oil and gas industry. Several companies are working together or are a part of the supply chain upstream and downstream.

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$^{91}$ 1 barrel = 159 Litre

Table 5.4.2 Total FTE in the oil and gas production sector

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTE[^94]</td>
<td>3630</td>
<td>3630</td>
<td>3170</td>
<td>2570</td>
<td>2420</td>
</tr>
</tbody>
</table>

The decreasing FTE per year (see Table 5.4.2) is an indicator for the decreasing production activities on the gas production sites. The decreasing oil and gas production offshore (i.e. DCP[^95]) and onshore are depicted in the figures[^96] below.

**Gas production in the Netherlands, 1960-2005**

![Gas production in the Netherlands, 1960-2005](image)

Fig. 5.4.1 Natural gas production 1960 – 2005

**Oil production in the Netherlands, 1960-2005**

![Oil production in the Netherlands, 1960-2005](image)

Figure 5.4.2 Oil production 1960 - 2005


[^94]: FTE = Fulltime equivalent for all employees working for the oil and gas producing company

[^95]: DCP = Dutch Continental Plate

[^96]: Source: [http://www.minez.nl](http://www.minez.nl) and [http://www.nlog.nl](http://www.nlog.nl)
As the conventional oil and gas production on the Dutch continental plate (DCP) is decreasing, the interest of exploiting marginal field is growing. Within the oil and gas regime several radical innovations are emerging to meet the requirements which are typical for the marginal field production. This will be discussed in the following section.
5.5 *Trend in the Netherlands: unlocking the marginal gas reserves*

Natural gas as an energy source is increasing much higher than that of oil. More proven resources containing natural gas have been found than oil. It is obvious that natural gas is “easy” to find but somehow not as popular as oil is.

In this chapter natural gas regarded as relatively abundant feedstock will be discussed. On the DCP, there are much more natural gas wells than oil wells. The majority of field discovered are the so-called marginal fields. There are many marginal fields that are owned by national oil companies but are never been exploited yet. The reason is that the oil companies that own many fields prefer to exploit larger fields because the risk is much lower and the investment on return are much higher. These companies are actually waiting for technological development to exploit these marginal fields with profit. The marginal fields have been locked by major oil companies for several years.

How can the marginal gas reserves be unlocked?
The investment in the North sea had to be stimulated by the government because waiting on technology is not really stimulating radical innovations within the oil and gas regime (i.e. regime optimization). Exploration and risk taking activities stimulates innovation in the marginal field niche. The Dutch and British governments have both adjusted their policies to stimulate exploration and production in the North sea. The national governments have a tax regime in order to stimulate oil companies to produce as much as possible. It is anticipated that without stimulation the incentive to produce hydrocarbon production would be low. The oil companies will use cheap and outdated equipment and will not exploit small fields. When an oil company is obligated to pay tax, a certain amount of gas must be produced to reach the break-even point. An oil company is obligated to use state of the art equipment to improve the production efficiency. The national governments grant subsidy to oil companies that own small fields. When these small fields are not exploited on time, the oil company must pay back the subsidy. At the moment the exploration and risk taking are being done by small ambitious oil companies acting as adventurous entrepreneurs in the North sea. KCI is specialized in providing these entrepreneurs fit for purpose solution for their activities.

Why natural gas is the future for the Netherlands?
The West-European countries are well aware of the fact that in the future more and more oil should be imported. The increasing energy demand will encourage exploitations of marginal fields, deep offshore fields and natural gas. Taking into account the environmental laws concerning the air quality, the current increase of natural gas discoveries and liquefied natural gas technology advances, LNG as feedstock could be the alternative for imported oil\(^7\).

Natural gas as new energy source?
The total natural gas consumption in the Netherlands will increase in the future due to the growth in electric power demand. The growth is due to increase of residential, commercial and industrial consumption of natural gas. The natural gas consumption level is influenced by:

- the natural gas price;
- purchase power;
- weather.

\(^7\) [Link to article](http://www.dft.nl/nieuws/877300/Rabo__Boskalis_favoriet_in_LNG.html)
The price of natural gas affects the consumption more than the purchase power and weather. The domestic natural gas user will be forced to reduce consumption when the price is high. Low prices will encourage the need for comfort and will lead to more consumption. Increase in purchase power and cold weather will also lead to more need for comfort but it correlates less strong with the consumption. The electrical power sector is sensitive to natural gas prices because natural gas can be substituted by other fuels such as coal, oil and nuclear power. The natural gas prices are high and will eventually remain high because the price coupled with oil. The high prices is stimulating the LNG technology and increasing the LNG distribution capacity (see appendix D). Natural gas as energy source has advantages and disadvantages.

The advantages are:

- Natural gas is a clean non-renewable energy source.
- There is less emission
- Less waste left after using. (Regarding the stricter environmental laws)

The disadvantages are:

- Remote area 
- Transportation problem 
- Energy added value is low

It can be concluded that the Dutch oil industry will focus (i.e. future trend) on the marginal gas fields. In the following section the relation between marginal fields and KCI will be discussed.
5.6 Marginal fields developing projects

The trend of the last decades is that large hydrocarbon resources in the North sea that produce easy accessible oil are at low production level or depleted and the new resources would not meet the increasing world energy demand. On the other hand regime transformation from the traditional fossil fuel (non-renewable) to renewable environment benign energy carriers is in the pre development phase. It will take with this slow pace at least 10 years before some transformation can be noticed. It is expected that the oil production will continue to decline and that the Netherlands must rely every year more on imported oil. According to the paper Stand der Techniek\(^\text{98}\) most of the existing oil producing platforms on the DCP will be out of service by 2010. However, the interest in exploiting marginal fields is growing. Ambitious actors supporting the traditional oil and gas regime have been creating niches for themselves. This niche experiments evolved into technological niche and niche markets that made marginal fields production feasible. The marginal fields on the DCP are mainly gas fields. A marginal field has a maximum peak rate of 1.2 million m\(^3\) gas per day. There are two types of marginal fields:

1. Fields that had been cream-skimmed (by the former owner)
2. Fields that have a low gas in place estimation.

1. Matured (Cream skimmed) fields

Matured fields are fields that were economically feasible. With the conventional technology or existing process hardware it is not possible to produce gas without risks of losing a lot of money. The conventional technology limitations could be caused by the low pressure in the reservoir or low gas flow (i.e. above maximum turn down of process equipment).

2. Low gas in place fields

These fields in general have in general the amount of gas in the reservoir that is below the anticipated minimum economical cubic meters.

In the 70’s and 80’s mainly the large resources have been exploited by using conventional oil and gas recovery technologies. The marginal fields were barely exploited. At the moment the DCP consists of depleted large resources and marginal fields.

5.6.1 Marginal field projects KCI

In order to define the process hardware or new technology required for marginal field production, an engineering company should have working procedures. In this section the general working procedure of KCI will be described and comparison with key processes of SNM will be made.

KCI as an engineering company is providing oil and gas companies operating in the DCP technological and economical solutions. The solution can be a cost estimate or a process technical calculation but also a design of a process hardware. Process hardware is an equipment or steel construction that will be used to make offshore oil and gas production possible and profitable. The MPP and SPS can be considered as process hardware.

When permits for drilling is arranged. The project manager of an oil company has already gathered information by the financial institutes or other group of investors and oil and gas specialists on marginal fields. The oil and gas specialists will present a basis of design to define the scope of that particular project. In the basis of design the purpose, the expectation and the engineering cost should be addressed to the project manager of the oil company. The basis of design contains basically all information for calculations and estimates that have to be done by the team which consist of process, electrical, piping and structural specialists.

Communication between the Oil companies and KCI is very important at this phase otherwise there will be a discrepancy between the information which KCI has based its calculation on and information expected by the oil company. During the project the communication will intensify because of the high generation of information and information exchange in a short time. Scope change is sometimes inevitable because the cost estimate is above budget the oil company had in mind. Budget cut down is the last resource and it is the engineers that have to come up with cost reducing solutions. When cost saving solution is not sufficient other available technologies or innovations should be applied. KCI will persuade the project manager of the oil company that the scope has to be changed. It could possibly be that the project manager was not aware of the difference in approach when dealing with marginal fields. The technical requirements for extracting gas from marginal compared to conventional gas extraction.

- low cost construction
- self installable platform
- compact equipment
- tie in into existing infrastructure or host platform
- unmanned thus not far from existing platform or shore
- module built installation and platform (easy for hopping)

The economical requirements for extracting gas from marginal compared to conventional gas extraction.

- return on investment
- high oil price (also feasible at low oil price)
This can be defined as energy to extract the gas must be less than energy the gas in the reservoir can provide. In the following sections the gas and oil production will be described.

It can be concluded that the key processes of SNM are incorporated in the working procedures of KCI. The expectation should be shared with KCI and scope changes are inherent of the learning processes that should take place.
5.7 **Global trend: Easy accessible oil is becoming scarce?**

Discussions about non-renewable energy (i.e. oil and gas) are already going on between the oil major oil companies (MOC) and environmental organizations (EO). Both parties are having explanation about the situation of the world events today. The environmental organizations have lost their credit after some way over the top doom scenarios. In this chapter this will be discussed. The EO’s base their future prospective upon actions and economical measures taken by the MOC. The following arguments are available for “end of easy accessible oil” and are worth thinking about:

- The amount of proved economic feasible recoverable oil reserves in the Middle east has declined while those of gas has increased and found evenly spread around the world\(^99\).
- New fields are found in a smaller number of countries than in earlier periods

- The most giant fields were found in the 1960’s. Nowadays with the improved seismological and geological technology fewer giant fields are found. Only in deeper offshore sea and Arctic location giant fields were found.
- Since the year 2001 the oil price has doubled from the average of $ 30 per barrel up to $ 60 per barrel. It’s more logical to expect that the OMP will spend more money in finding more oil and gas resources. Nevertheless the following unexpected actions are taken place:
  - Oil companies have only increased their budgets for new field exploration by a small percentage\(^{100}\).
  - Another trend is that the OMPs are replacing dwindling reserves by acquiring other oil companies.
  - The main objective of the OPEC organization is to control the oil price by controlling the oil production. The refineries of countries which are not members of the OPEC are working close to capacity, yet no new refinery has been constructed for years.
  - The oil tankers which are rented ships are fully booked because the U.S and European countries ship the oil from the Middle East and West Africa. Still there is no orders to build new ships but only decommissioning of outdated ships
  - Exploring for new fields which suppose to increase the amount of oil and gas to sell at the recent prices and also to increase the company’s shares on the stock market is not as important as in 1990.


\(^{100}\) Source: [http://www.technologyreview.com/Energy/14178/](http://www.technologyreview.com/Energy/14178/)

Author: M. Williams, technology review, February 2005
• It is also a trend to own the upstream (oil exploration and transfer) and downstream (refining and marketing operation) which is named integrated oil companies. This strategic measure is to spread the risk. Apparently oil exploration and transfer is not as profitable as in the past.

• The total capital expenditures on new field explorations have decreased while the profit was increasing throughout the years. Due to these measures the rate of new oil field discoveries has decreased in recent years. The exploration costs have been higher than the net present values of the discoveries.

• There is a huge challenge to produce more oil and gas to meet the demands of China and India. If the oil consumption reaches one quarter of that of the US the world production would have to rise with near to 50%. There are still no serious attempts to meet these requirements but major are acting as if the oil reserves are finite. There are more measures taken to maximize the profit and to control as much possible the oil around the world.

These abovementioned issues indicate that the investment in exploration would never be paid off. It is better to control or possess as much oil as possible because there is probably not significant oil to be found. China is trying to buy existing oil fields in every continent but is hindered by the existing deals. China has even made offers to purchase large interest in Alberta’s tar sands however this alternative oil recovery is not profitable yet.

The access to nuclear technology is the reason for the growing tension between the USA and countries like Iran and North Korea. The interest in nuclear technology is an indication that these two countries are busy doing research on alternative energy. On the other hand, the nuclear technology can be used to create nuclear weapons. To be able to control oil fields, it will be easier for a country when it possesses nuclear weapons. This also indicates that military clashes in the future would be about the imbalance of oil consumption and oil control.

Then, like in 1973, countries that don’t want to be dependent of the oil controls would do more effort to recover oil with new technologies or will be forced to implement renewable energy. Despite of the expected tightening of environmental laws, the growing world population and economical growing countries as India and China will sustain the growth of oil demand.
5.8 Trend of big oil companies

Large industry trends affect incentives for MOC's to maintain production in the North sea region and may make it advantageous to sell their fields to SME's at a very low price. Such decisions are not driven by the level of productivity of fields but by issues of amortization of equipment, the potential costs of decommissioning (hence, the advantages of extending the lives of rigs in the hands of independents SME's) and accounting considerations. It can be concluded that MOC's exploit the most profitable fields first, and then leave marginal fields because the corporate tax regime makes it un-economical to produce them. This implies there is the potential of many more fields being developed when adventurous entrepreneurs get the chance to develop marginal fields and hence likely this will increase the total tax revenue to the Government.

In the meanwhile the search for large oil fields continues. Shell for example will start producing from very deep sea field in the Mexican gulf. The fields Great White, Tobago en Silvertip will produce in 2010 about 130 000 barrels per day. These fields are located 350 km south of the coast of the state Texas (Freetown). This project is a depth record for a spar production platform. The spar type production platform will be positioned by anchors. There are some major technical challenges, the seabed is very rough. Pipeline laying and positioning of sub sea equipment will be very difficult to do. However, oil and produced liquids separation will take place subsea. A special oil and gas separation system will separate oil and gas. The oil will transferred to the production platform with booster pumps and the gas will flow naturally upwards to the production platform. There are more oil companies investing in the deep sea and subsea technology however they face many challenges and uncertainties related to the application of this technology. However some of the equipment is perceived as proven technology, limited operational experience in subsea application is available.

Moving into deeper water, subsea system interventions become more expensive and are associated with long lead times. The required heavy transportation and pipe lay vessels are very scarce and expensive. However, the high oil price and growing energy demands will stimulate the building vessels and subsea intervention.

According to Shell, Shell faces global competition with ExxonMobil (see appendix G), BP and Total and regional it should deal with British and American independent SME's and NOC's as Hydro, Statoil, Petrobas and Petronas. High oil price has an advantage and a disadvantage for a major oil company. The advantage is that the revenue will increase. The disadvantage is that the competition will offer higher bids for oil fields to gain more acreage.

Another problem is the decommissioning of conventional platforms on depleted oil fields. The oil companies don't want to spend much money on decommissioning of platforms. However, no oil company wants to face global protest initiated by environmental groups as Greenpeace. Now sinking of platforms to provide aquatic habitats is a way to meet the requirements of environmental groups. The biological question will be: would sunken platforms actually provide biological benefits?

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102 http://www.dundee.ac.uk/cepmlp/car/html/car3_article2.htm
103 http://www.deingenieur.nl/nieuwsDetail.lasso?ID=3740&session=NTses:C2233B0E9EBA9139A73533BC57111D59
104 See appendix I: Mr. M. Bichel; Head of Global exploration department of Shell
5.9 Conclusion

In this chapter oil regime of the Netherlands was analysed. The oil and gas production onshore and offshore was assessed. Thereby, the trend of this fossil fuel regime was analysed in order to achieve a glimpse into the future development of this industry. It is graphically displayed that the Netherlands has much more gas than oil production. The Dutch oil and gas industry will focus more on the gas production and innovations related to marginal gas fields. Unlocking of the gas reserves in the North sea using new technologies as MPP and SPS will change the face of the gas industry. There will be more possibilities for SPS when the subsea gas compressor is fully developed and more offshore vessels for heavy equipment transportation are built.

The Dutch sector has been owned for many years by major oil companies (MOC's). These MOC's had no incentives to exploit marginal fields as they exploited only the economical fields. The SME's (supported by national governments) have been buying these marginal and matured fields from big companies as Shell. These SME's are more willing to take more risk and apply new technologies in order to enhance the NVP of the fields they exploit.

The global trend is: the great concern about the dependency of oil import and the lack of large oil fields discoveries. The MOC's as for example Shell are optimistic because they believe that there are much hydrocarbon to find at remote area (see appendix I). The lack of qualified personnel at this moment and in the future is their greatest concern. The oil fields in remote areas (e.g. Arctic area) will be found soon but there will be not enough skilled engineers to provide the adequate technology. The interviewees (see appendix B) argue that the lack of personnel is because of the fact that offshore engineering has a bad image.

In the next chapter the necessity of regime change will be investigated. Regarding the results, an energy transition is not expected but in this case the regime should change in order to make emergence of promising and new technologies possible. The emerging technologies as SPS and MPP can be used to recover hydrocarbon in remote area or small fields to meet the exponentially growing energy demands of societies (advanced economies and developing countries) worldwide.
6. Regime shift analysis

6.1 Introduction

In this chapter the existing technological regime will be analyzed because the established technology has influence on the development and the diffusion of a new technology (e.g. MPP and subsea processing system). In general, the new technology should be widely accepted in the existing society. As described in chapter 2, a combination of societal and technological rules (i.e. regime) should be adapted in order to widely accept the new technology. A radical innovation requires new societal and technological rules (i.e. regime shift). In case of a regime optimization the technology has the same purpose (i.e. incremental) but complies with the new regulation or desire of the society.

The combination of existing societal and technological rules, also known as the socio-technical regime is discussed previously in section 2.3.2. It should be noted that regimes have influence on the development of new technologies whether the technology diffusion results in regime optimization or regime change. In section 6.3 the regimes that play major role in the development of MPP and SPS will be described. A dominant regime can be perceived as a barrier to entry for an emerging technology. The existing regime analysis should give the reader insight of the dominance of the regime. When a regime is dominant, the actors within the regime will have no interest in the new technology. In case that the actors involved in the development of the new technology managed to persuade the actors within the dominant regime, the actors could provide resources and significant support that can result in a product diffusion.

In this chapter the multi level perspective (MLP) will be used to explain how the subsea market niche can develop into a dominant market in the future. According to the MLP a regime transformation must occur before the subsea technology achieve a significant market size increase. Interviews, surveys and literature research (see appendix B) will be used to answer the following questions:

1. What are the roles of the actors?
2. What are the chances and treats per actor?

The actors-network (see section 4.4) will change during the regime transformation. The important actors and their role will be discussed in the actors-network map.
### 6.2 Socio-technical regime and other regimes

When a technical or economical change takes place offshore (upstream), it will be noticed onshore (downstream). If for example in the Netherlands the oil price rises, it will immediately affect revenue of the Electric power companies (e.g. Gasunie and Nuon), the Heating companies (e.g. Eneco), Gas stations (e.g. Shell and BP) and Crude oil derived chemical producers (e.g. Dow chemicals and Akzo Nobel). The consumers (i.e. society) will have to pay higher rates (the prices of gasoline, heating, electricity and chemicals will raise).

The SNM approach and Multi level perspective provide information about the influence of the technology on the society but also the influence of the society on the development of the technology. The niche development in the offshore oil and gas industry could be supported by the society because it meets the needs of the society (e.g. increasing energy demand and wealth). According to the KCI engineers and managers (see appendices A and C) the influence of the society on the MPP niche development is insignificant. The interviewee of TUD, appendix B-1, argues that during the niche development of subsea technology the influence of the society was also insignificant. However, there are regulations and restrictions (i.e. socio-technical regime). In the Netherlands, oil companies are not allowed to exploit big gas fields in Groningen. In Figure 6.1 the relation between the socio-technical regime\textsuperscript{105} and the regimes downstream the oil and gas industry can be depicted.

Thus, regimes downstream the oil and gas industry have more direct influence on the society than the oil and gas industry. The society will protest against the high rates and within these regimes a new technological niche can be created to meet the new requirements of the society. The governmental organization as Dte\textsuperscript{106} will intervene when the consumers are paying too much (above agreed tariff). Alternative policy will be applied to influence the market power of major actors of the regimes. It can be concluded that the regimes downstream the oil and gas industry have influence upon each other and the socio-technical regime has influence on these regimes.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure6_1.png}
\caption{The regimes depending of the oil and gas suppliers and society (socio-technical regime)}
\end{figure}

However, when a new technology emerges in the oil and gas regime, it also has to create a niche and develop into a widely accepted technology. Therefore, an internal regime

\textsuperscript{105} the pattern that emerges from dominant practices based on rules and standards embedded in actors (e.g. scientists, policy makers, social groups and engineers) and artifacts (Geels 2004)

\textsuperscript{106} Directie Toezicht Energie
transformation (i.e. regime optimization) must take place. The existing rules and way of oil recovery change, to facilitate the emergence of the MPP or subsea technology. The regimes downstream the oil and gas industry can influence the rules and way of oil recovery indirectly (i.e. oil and gas regime) by threatening to use alternative energy. This will be the incentive for NOC's to extract oil and gas from marginal fields, deep sea or remote areas. It can be concluded that regimes downstream can initiate the internal oil and gas regime transformation. The regime transformation that takes place is similar to the dynamic model of transitions of Rotmans (see Figure 2.3.5) of section 2.3.5. This required regime transformation did not take place after introduction of the MPP. According to the energy analyst Douglas-Westwood Ltd, the conventional oil and gas technology will be substituted as the easy accessible oil and gas wells are becoming depleted by the subsea technology because of the high energy demand and high oil price. The Subsea sector is set for an explosive growth

6.3 The role of the actors

The expectation in a regime optimization caused by MPP niche development is very low (see appendix A) since low cost applications as monotowers (i.e. small platforms), subsea interventions and other self installable platforms, entered the market of marginal fields. The amount of actors supporting MPP technological niche will decrease as the amount of actors supporting the subsea technology is increasing rapidly. In the UK and Norway the subsea niche development is well supported by the government (see appendix B). Subsea UK is a member group supported by the Department of Trade and Industry of UK. In Norway the organization DEMO 2000 has a similar aim. The Dutch government stimulates the actors involved in applying new technologies to unlock marginal fields, by granting subsidies. Subsea UK has conducted a survey to address the skills shortage. The survey indicated that the subsea sector in the next few years would need more than 3000 skilled engineers. Subsea engineers, is thus needed all over the world. The higher educational institutions (HEI) and the media should polish the image of the oil and gas industry because it is perceived as not cool industry. The Robert Gordon University, in conjunction with Subsea UK is offering online courses to help oil related companies to decrease the shortage of qualified personnel.

107 Douglas Westwood
108 http://www.rgu.ac.uk/files/Subsea.pdf
6.4 Chances and threats to the actors

In this section, the opportunities for and the treats to actors involved in the MPP and SPS niche market will be described.

It is one of nature’s ironies that the most plentiful and prized resources so often occur in environments that are inhospitable to man. Perhaps the ultimate test is to be found beneath the surface of the world’s oceans, where the needs of the energy industries pose ever greater challenges to our ingenuity and adaptability.\textsuperscript{109}

The emergence of more actors into the subsea market niche results in more resources and market size increase. Developing countries Africa (e.g. Nigeria), Brazil and the Caribbean can now exploit their oil fields. This also brings about interaction between major oil companies and NOC and national governments of those countries.

Oil companies, when operating offshore have less interaction with the societal group or military clashes of rebels (e.g. Nigeria river delta) inland than companies operating onshore. The growth of deepwater exploration and production in the Gulf of Mexico, West Africa, South America, Southeast Asia, as well as the UK North Sea is triggered by the subsea technology and high oil price. Even mature sectors, where subsea tiebacks\textsuperscript{110} can exploit the remaining reserves, are growing. Subsea tiebacks are also preferred over the self installable platform (MPP).

Another trend is refurbishment and re-use of topside with equipment\textsuperscript{111} included. In the North Sea the French oil company Gaz de France is implementing this approach to exploit small

\begin{figure}
\centering
\includegraphics[width=\textwidth]{actors-network-map.png}
\caption{Actors-network map; old and new actors (ex-ante analysis).}
\end{figure}


\textsuperscript{110} A subsea tie-back is an underwater pipeline that delivers oil or gas from remote producers (e.g. recovery ship, floating platform etc) to a central processing plant (oil/gas platform etc). The remote plant is "tied back" to the processor, hence the name. Source: [http://www.proz.com/kudoz/1233413](http://www.proz.com/kudoz/1233413)

\textsuperscript{111} The platform and equipment will be re-used. The structure will be replaced by a new structure.
fields\textsuperscript{112}. This option is preferred over the self installable platform (MPP). KCI has conducted case studies, cost estimations and engineering for refurbishment projects.

The oil companies are hesitating to be the first users of new technology because they don’t want to face all the risks and uncertainties. Major environmental damage because of malfunctioning during the testing of new equipment may lead to protest from the societal groups as Greenpeace. This will damage the image of the companies involved in that operation.

Subsea booster pumping, both single phase and multiphase (i.e. boosting of gas, solids and liquid) have been deployed in several areas of the world including the North Sea, West Africa and the South China Sea. These systems are limited to the local water depth and required pressure boosting capabilities. For application in much deeper waters as in the Gulf of Mexico, the system should be optimized to the local conditions (i.e. water depth and required pressures). Theoretically, wet gas compression could be the piece of the subsea “missing link” that might change the face of the industry\textsuperscript{113}. Another challenge is that the power supply, electrical penetrators\textsuperscript{114} and connectors have to be optimized.

\subsection*{6.5 Different patterns of transitions}

In this section the multi-level perspective will be used to investigate the relation between market introduction of new technology and the stability of the regime for both cases (i.e. multi purpose platform and subsea technology). The niche development of both technologies will be assessed and a position in the two-by-two matrix will be determined. The characteristics of both niche developments are determined by studying the SNM and MLP. The characteristics of a good quality of key niche processes (SNM) and the factors that determine the regime transformations were summarized in the KPQI list (see section 2.6.6).

In Figure 6.5.1 the four quadrants that represent the four patterns of transformation can be depicted. The two-by-two matrix is used to illustrate the characteristics of the four patterns of transition which is discussed by Raven (2005) and Geels (2002). The two-by-two matrix used in this research differs from the matrices of Geels and Raven. The characteristics of the 4 patterns (i.e. four quadrants) are basically identical to Geels. For example the “peat more fire detour” pattern is described by Geels as the situation in which a new technology emerges into a stable regime. The definition of a stable regime is: the regime experiences no problems. The regime actors have no incentives to invest in the new technology. The new technology is used only in small niches. The technology will be further developed “below surface” as a peat more fire.

The difference is that the horizontal axis which represents the emergences of functionality is replaced by market size. Moreover, the description of the characteristic of all four quadrants (see Fig.6.5.2) is adjusted and is based on four measurable and comparable factors which are:

\begin{itemize}
\item http://www.energie.nl/index2.html?eii/informatie.html
\item Electrical penetrators are used to transmit electricity, usually at high voltage and high amperage (e.g., 5,000 volts at 150 amperes) through barrier walls of bulkheads, pressure vessel housings, wellheads, downhole packers, etc
\end{itemize}
1. Interest of regime actors in the technology (i.e. incentive to investment)
2. Expectation (e.g. is it widespread? High? Low?)
3. Market size (is it small or big?)
4. Development phase (market niche, technology niche or regime transformation occurs?)

Figure 6.5.1. Four patterns of transitions, after market introduction of a new technology based on Geels (2002).

In order to place the new technology in one of the quadrants, the characteristics of each pattern must be available (see Figure 6.5.2). The required information for the transition patterns is obtained by interviewing experts (see appendix A and B) and literature research, using ideas of Weber et al. (1999), Geels (2002) and Raven (2005).
The characteristics of both new technologies are also determined by means of interviews and literature research. In order to illustrate the development of the new technologies of the last decade, the new technologies will be given twice (year 2000 and 2010) in the two-by-two matrix. The matrix illustrates the MPP technology emergence into the market dominated by fixed platforms in the late 1990’s. Now, in 2007 the interest in the MPP is diminished. In contrast to the MPP, the subsea technology was an option with high CAPEX (i.e. uneconomic) in the late 1990’s and after the oil price passed the $60 per barrel, subsea technology became economical. The result of the research is given in the table below.

Table 6.5 The characteristics of the transformation patterns in 2000 and in the future for both cases (MPP and Subsea)

<table>
<thead>
<tr>
<th>Case 1: MPP</th>
<th>Year 2000</th>
<th>Regime: incentives to Investment</th>
<th>Actor: Expectation about future potential</th>
<th>Market development</th>
<th>New technology development phase</th>
<th>Regime stability towards new technology (MPP or SPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weak</td>
<td>Low</td>
<td>Creation of Small Market niche</td>
<td>Market niche</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Case 1: MPP</td>
<td>Year 2010</td>
<td>No</td>
<td>Small Market niche</td>
<td>Experiments and technological niche.</td>
<td>Very stable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weak</td>
<td>Low</td>
<td>Creation of Small Market niche</td>
<td>Experiments and technological niche.</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Case 2: SPS</td>
<td>Year 2000</td>
<td>Weak</td>
<td>Capturing significant market share</td>
<td>Internal oil and gas regime transformation</td>
<td>Unstable</td>
<td></td>
</tr>
<tr>
<td>Case 2: SPS</td>
<td>Year 2010</td>
<td>Strong</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6.5.3 The development of the MPP concept of the last decade.

Figure 6.5.4 The development of the subsea technology of the last decade.
During the past four decades, subsea-well-completions technology has grown from untested engineering theory to viable, field-proven equipment and techniques that are accepted by the petroleum industry and the national governments of producing countries (see appendices E and F). In the 37 years since the first systems were installed, approximately 1,100 subsea wells have been completed\textsuperscript{115}.

The regime is unstable towards the SPS and the market size increases. The subsea technology can be considered as a problem solver (see Figure 6.5.4). It can be concluded that the MPP has left battle-zone and entered the low diffusion zone (see Figure 6.5.3). The emergence of alternatives for marginal fields (i.e. unmanned monotower structure, subsea wells and other self installable platforms) stopped the MPP emergence. Therefore, the market size of the MPP has declined.

\textsuperscript{115} http://www.spe.org/spe-app/spe/jpt/1999/08/frontiers_subsea_completions.htm
6.6 Conclusion

According to the research using MLP, the MPP did not manage to create a significant market niche. However the subsea technology is capturing market share. The MPP is technically limited to the footprint and water depth. According to Energy analyst Douglas-Westwood, the major challenge is now, developing deepwater projects at a reasonable CAPEX. The dominant actors in the transformed oil and gas regime will remain the oil companies and the suppliers of subsea equipment. The actors of subsea technology-pull are the oil companies and the suppliers of subsea equipment and developing countries (India, China, West Africa, Southeast Asia, South America and the Caribbean). Technology-push actors are the national governments, financial markets, engineering companies (e.g. KCI). Opposing actors will be the societal groups that would be concerned with the deep sea explorations and technical failure of equipment on the seabed.

In this chapter the MLP is also used to analyzed the existing regime and perform a regime shift analysis. A regime shift is a change in the existing set of dominant practices, rules, legal decision-making systems, way of thinking and assumptions embedded in human actors that leads individual actions and public policy (see section 2.3.2). This change should occur so that the new technology can be widely accepted. It is investigated whether there are more regimes that can influence the diffusion of new technologies related to oil and gas industry. These regimes are identified but their influences are not within the scope of this research. One regime analysis approach is considered as sufficient during this research.

In this chapter, the role of the actors (regime analysis) is investigated in order to predict whether the actors will contribute or oppose the niche development of the MPP and SPS. It is assumed that actors will assess their chances and treats before they get involved in the development and application of new technology. Another way of stimulate the diffusion of a new technology is to follow the characteristics of transition management. Transition management includes constantly monitoring and adjusting the development towards the goal. The actors involved in the MPP and SPS projects also use the transition management characteristics in order to reach their goals and visions. The goal is now to invest more in SPS and there is less interest in surface platforms as MPP. In this chapter the regime stability-market size matrix is introduced in order to illustrate the characteristics of a niche development. This transition patterns also illustrate also the movement of the MPP and SPS niche. The situation in the years 2000 and 2010 are given in the transition pattern. The movement on the transition patterns are caused by other emerging technologies (i.e. competition), expectation of the actors, change in regime stability due to changes on landscape level (MLP) and marketing efforts (this will be discussed in the following chapter).

According to UK's Trade and industry secretary\textsuperscript{116} the future of energy supply situation will change, but it is clear the North Sea will remain critically important. The Western European countries could be importing as much as 80 - 90% of their gas. The answer lies in using the offshore areas in the North Sea more cleverly. New technologies as MPP and SPS could provide life extension of platforms. European legislation needs to be updated to ensure that new technologies related to offshore industry could take advantage of (i.e. changes on

\textsuperscript{116} Mr. Alistair Darling is Trade and Industry Secretary; source: http://www.gmn.gov.uk/environment/fullDetail.asp?ReleaseID=275035&NewsAreaID=2&NavigatedFromDepartment=False
landscape or regime level is necessary). In the following chapter the technology commercialization approach will be used to investigate the added value to SNM and MLP.
7. Technology commercialization approach

7.1 Introduction

In this chapter it will be investigated if the five technology commercialization stages (TC) of V. Jolly has added value to the SNM approach and MLP. As described in section the TC includes the technology commercialization dynamic process that proceeds through five stages, which are:

1. imagining
2. incubating
3. demonstrating
4. promoting
5. sustaining

7.2 Added value of the technology commercialization approach

In section 2.5.1 Jolly (2000) introduced 9 activities which are considered as typical where things could go wrong. The added value of the technology commercialization approach will be discussed in this section. The SNM argues about the quality of key processes to avoid the following activities mentioned by Jolly:

1. Linking to a worthwhile exciting market opportunity (coupling expectation)
2. Endorse the technology during the niche development by actors (actors-network)
3. Incubating the technology to understand the true potential (learning process)
4. Mobilizing resources (actors-network building)
5. Demonstration (learning process and actors-network)
6. Mobilizing the market constituents needed for gaining market acceptance (actors-network)
7. Promoting and confront sceptical users (learning process and broaden actors-network)
8. Choosing an appropriate business formula for gaining access to the required business system;
9. Sustaining commercialization so as to realize value from the technology after it has been launched.

Activity 6 is a good example to illustrate the similarity between SNM and TC approach. Both argue that a broader actors-network is required when the inventor is aiming at wider acceptance. However, Jolly gives three sets of new actors that should be mobilized, which he named market constituents:

- companies that can be engaged in the delivery;
- advocates and/or arbitrators that play a role in its market acceptance
- companies that already are commercializing the incumbent technology.

Activities 8 and 9 are not included into the SNM neither the MLP. Both theoretical concepts focus on the development of a new technology and not on the commercial activities what are required to maintain client/user and inventor relationship. The technology commercialization approach gives a clearer view of the whole commercialization process. The SNM approach and MLP do not give specific practical examples but gives the designer which processes should be of good quality. SNM and MLP don't explain exactly what should be done to achieve those goals. The TC provides the designer practical activities in every stage. The TC is based on a piece-meal approach while SNM and MLP are major chunks. The combination of theoretical concepts and practical activities will lead to a balanced KCI business strategy. In the sustaining commercializing process stage the designer should consider to monitor market trends, maintenance of the product (e.g. MPP), problem solving and provide service after commissioning. These activities are important for KCI in order to deal with the threat of substitution (competition with other designers or new or existing technology.

7.3 Findings of the technology commercialization research

The first 7 activities according to Jolly (2000) are incorporated in the KPQI criteria. The 8th and the 9th activities are added separately during interview, survey and meetings. The MPP should be promoted by in order to deal with the threat of substitution by emerging technologies. According to appendix A, Overdick manage to make a deal with its clients to avoid its products being substituted by the KCI's MPP. It might be the case that KCI did neglect the MPP a bit because it is not KCI only products as it is for Overdick. The TC also argues about business formulas and access to business systems.

An example for a business formula is having a slogan for the typical KCI product as the MPP. Another example is to gain acceptance into other market segments. For example the knowledge gained during the learning processes can be used in other market segment which might have nothing to do with offshore oil and gas engineering. A typical example for this is offshore wind energy and great wheel projects which are large based on the building of structure for fixed platforms.

7.4 Conclusion

In order to generate a business strategy for KCI, the practical activities of TC give better explanation. SNM and MLP are rather similar to the TC but they lack explanation about how to sustain the product after the market introduction. SNM and MLP are very useful before niche creation, during the niche development and when a significant market niche is created. The SNM and MLP don't pay attention to clever commercial activities to maintain the dependency of the client to the designer. The TC will advice companies that are involved in the subsea technology to not to neglect the client after the market introduction. The designer should be aware that the other designer may threaten to substitute the products in the fields. This is the reason that MPP did not manage to find more clients. The MPP is in fierce competition with other Self installable platforms (e.g. SIP, Monotowers and Subsea processing systems). In the following chapter the conclusion and recommendation of this research will be described.
8. Conclusion and recommendations

In this chapter the conclusions and recommendations will be described. First the research questions will be answered in section 8.1. In section 8.2 the summary of the conclusions of chapters 3, 4, 5, 6 and 7 will be described. In section 8.3 the recommendation will be described. The recommendations are directed to KCI about how to manage the MPP-niche and why KCI should believe in SPS. The recommendations are based on the three theoretical concepts which are SNM, MLP and TC.

8.1 Answers to the research question

How can the niche market of oil and gas of marginal fields in the North sea be stimulated by using the strategic niche management approach?

From this main research question the following sub questions should be answered:

1. What is the quality of niche processes in the cases of multi purpose platform and subsea processing systems?

In general, the SNM key processes of both cases are of good quality regarding the hypothesis (see 1.4). The KPQI is used to determine the quality of each key process. With respect to the MPP, the quality was good although improvement of the qualities of the key processes was required for the next generation of MPP’s. The learning process can be beneficial for the MPP development in the future. The actors-network was aligned but no attention was paid on broaden the actors-network that could have boosted up the interest in the MPP. The expectation on the niche level was high but for a successful market introduction the expectation on the regime level should also be high.

With respect to the Subsea technology, the expectation is much higher than the MPP technology. The subsea is gaining market size because of the energy demand and high oil prices that made uneconomical remote fields very attractive to oil companies and investors (i.e. actors-network). The other alternatives (oil sands and natural gas as feedstock) are respectively too expensive to operate due to the high CAPEX and OPEX costs. The LNG is still in the development of the infrastructure phase. The latter means that special transporting ships, storage location and processing location have to be available first. It is expected that the subsea will change the face of the industry while the alternative energy sources, tar sands oil recovery and LNG remain uneconomical. It can be concluded that the quality of the key processes of SPS is much better than that of the MPP because of the higher expectation (i.e. measured by the investment into the SPS technology), broader actors-network (measured by the amount of projects and oil companies involved in the niche development) and better quality of the learning process (measured by the amount of test beds and applications worldwide).
2. Which development occurs in the socio-technical regime of offshore oil industry?

The information about the development is studied by using the MLP. According to MOC’s and TUD interviewees (see appendix B) there are enough hydrocarbons to be found in remote area (e.g. Arctic area and deeper sea). The lack of personnel will be a problem in the future while the energy demands increases and high oil price makes marginal fields economical.

Transition patterns in chapter 6 illustrated that the MPP has shifted from a promising technology to a dead-end technology. MPP is replaced by mono-towers and subsea processing systems. The subsea processing systems have shifted from promising technology to problem solver. According to the peak-oil theories the oil resources are declining (The North sea oil production peaked in the 1990’s). The oil majors are collecting acreages and keeping oil wells waiting for higher oil prices. In the meanwhile the oil regime is going into deeper seas and further from the shore.

3. How and why can SNM be used in the case of regime optimization?

SNM can be used in the case of offshore oil regime optimization by analysing the key processes (e.g. expectation coupling, actors-network and learning processes) that occur during the niche development of oil regime related promising technologies (see section 4.6). With the MLP, the influences of the macro- and meso levels on the micro level (i.e. niche level) can also be analyzed. These theoretical concepts help to explain the result of the market introduction. In this research the SNM and MLP are used to explain the market introduction results of the MPP concept (ex-ante analysis) and of the SPS (ex-post analysis).

The transition from conventional offshore technology towards MPP or subsea technology is considered as a multi level dynamic process towards the transition goal which is to stimulate marginal oil and gas fields in the North sea. The difference between using the SNM approach for studying the niche development of radical innovation and incremental innovation is that the learning from the society and adjusting the new technology to the society are less important in the case of incremental innovation (i.e. regime optimization). The dynamic processes which are normally used for describing the energy transition (i.e. fossil fuel based energy towards sustainable/renewable energy) can be used for the description of the dynamic processes during the introduction of new technology to the existing offshore oil regime.

The exponential increase of SPS application (i.e. successful market introduction) is explained with SNM and MLP. The unsuccessful market introduction of the MPP is also explained with SNM and MLP.

It can therefore be concluded that emergence of new technologies in general requires good quality of niche key processes. Product development, market introduction and product acceptation can be considered as a transition process. For a radical innovation to be successful a radical societal change and regime shift are required. In the case of incremental innovation (e.g. introduction of SPS and MPP in the offshore oil industry) the required societal change and regime shift are negligible.
8.2 Conclusions

Conclusion of the conceptual framework

In this research, two case studies were performed by using the theoretical concepts which are SNM, MLP and TC. These case studies are described in the conceptual framework. The following can be concluded of the theoretical concepts:

- The SNM approach gives KCI insight in the key processes of the niche development of the MPP and SPS. A good quality of these processes (i.e. coupling expectations, actors-network formation and learning process) is required for a successful market introduction.

- The MLP gives KCI insight in the external processes (i.e. regimes and landscape) that influence the niche developments. The regime and landscape level can also influence the expectations of the actors. The actors are more confident when for example there is a regime shift (e.g. in this particular research the oil industry requires new technologies as MPP or SPS) as result of changes in the landscape (e.g. when national governments implement policies that favours subsea mining).

- The TC is similar to SNM and MLP but the added values of TC are the key processes after the market introduction.

The SNM approach is a tool to analyze niche development projects but is not a project management guide. By using the SNM approach it is not possible to predict the diffusion of a new technology. The SNM approach applied on regime optimization cases should be developed further in the future. In this research the KPQI list and the TC checklist are developed and used in order to conduct this research. This is to prevent that key process that should be assessed will be left out. The TC is also incorporated into the conceptual framework in order to understand the commercialization process better. SNM and MLP don't provide a trajectory of activities that one must follow from creating a niche until post-market launch. The key issues that can improve the quality of each SNM key processes are summarized in the KPQI list. These key issues increase the likelihood of a successful market introduction of a new technology (i.e. incremental and radical innovation).

The MLP is used to describe the transition from a conventional or existing technology towards new technologies. This requires a regime change so that the new technology can be widely accepted and applied. It can be concluded that the oil and gas industry have an aggressive regime optimization program. The regime shifts (i.e. in this particular research the new technologies optimize the offshore oil industry regime and transform it into more dominant regime) and the landscape (i.e. mining regulations and EU legislation) changes in order to make explorations in remote area economical. That gives opportunities to the developers of new technologies as subsea processing systems. On the other hand due to this regime optimization, this offshore oil and gas industry regime becomes more stable. This makes it more difficult for sustainable / alternative energy based technologies to emerge.
Conclusion of this research

For many decades, the oil and gas industry has pushed the limits of innovation. Through hard work, creativity and “out-of-the-box” thinking, extraordinary new technologies have been developed to find and produce offshore oil and natural gas. KCI, just as many other engineering companies has also contributed to the technology advances and diffusion of new technologies and concepts through its clients. The external pressures upon the existing fossil fuel energy regime are building up throughout the years. Many European nations imposed for example pollution taxes, however the oil and gas industry still managed to arrange agreements with the national governments (i.e. lobbying and rent seeking). This way of regime optimization is not desired by the society. The society is well aware of the fact that transition towards alternative energy will have cultural and behavioural impacts on the society. However, the society is not willing to pay more money or change its habits for alternative energy on short notice. In the meanwhile major oil companies are searching for more hydrocarbons at remote area, continuously focused on influencing national policies and focused on realizing regime optimization. It should be noted that the regime shift in this research should not be mistaken with regime shift required for energy transition. In the transition patterns (see chapter 6), the unstable regime is still stable for sustainable technology.

Alongside the MOC’s, small companies are introducing new technologies, linking up and developing new fields. The European governments back that with new licenses available for small companies that have adventurous ideas. This pioneering spirit has to be stimulated and rewarded according to Trade and industry secretary of UK\(^\text{118}\). The tax regime should be changed in a way that small fields can also become economical. However, the tax regime cannot be abolished completely because otherwise the production would be at a low level. Thus, the tax regime should be optimized by the EU countries in order to encourage exploration and production in the North sea (i.e. regime optimization). Nevertheless, in some countries that have very good geology, it remains attractive to invest in marginal fields even under high taxation regimes. The effect of tax regimes depends of the country and location.

It seems that SPS has a better chance in being widely accepted than the MPP. The SPS has the advantage that it operates in remote area, deeper waters and is unmanned. The SPS is also economical because it doesn’t require structure. The market size and the amount of applications are used to quantify diffusion of a new technology. The SPS actors-network is much bigger that of the MPP. There are also much more SPS “test beds” and applications than MPP applications. It can be concluded that the market introduction of the MPP is not successful whilst the market introduction of the SPS is a very successful (see transition pattern of chapter 6).

With respect to the societal groups, it can be concluded that the influence of the society on the market introduction of MPP and SPS is minimal. There are some actions of the Greenpeace and Milieu defensie (see appendix H and K) however the impacts of these actions are not significant on the long run. SNM is traditionally used to find out whether the society and/or societal groups can influence the market introduction of a radical innovation. It can be concluded that MPP and SPS technologies are incremental innovations (thus provides offshore regime optimization) and therefore the societal groups, NGO’s and society merely influence the diffusion of these technology. The result of the MPP niche development research which was based on the SNM approach (using the KPQI list) is that the influence of

\(^{118}\) Mr. Alistair Darling; http://www.gnn.gov.uk/environment
the society was minimal. As described in section 2.3. for a transition to take place (i.e. regime transformation) the requirement of the society should be met and learning from the society during the niche development is very important. That will increase the likelihood of a successful market introduction. However, in this particular research the conventional technology is replaced by new technology but the purpose (i.e. fossil fuel production) is identical. When a technology is introduced with a different purpose (i.e. wind energy) a technology will face criticism and bad cooperation from the society. The society should play a bigger role in the niche development of radical innovations according to SNM.

The result of the questionnaire
The results of the questionnaire based on the KPQI and TC checklist are displayed graphically below. In appendix A and B the results of the questionnaire are given per interviewee. The responses (yes, no or no answer) of all interviewees are counted and displayed graphically in Figures 8.2.1 and 8.2.2. It can be concluded that the engineers agree about the fact that knowledge from patents, experts and existing platforms is used (see question code TB.1). Also all engineers were confident at that time that the MPP has many advantages(see question code SP.4). The expectation was high at that time (see question code VE.1). The management also agree that the MPP concept needs more marketing and more successful applications (i.e. test beds) (see Appendix A-5; question 5). The communication was optimal but the learning processes did not include learning from the competition. Furthermore, the learning process did not include commercialization after the market launch.
RESULTS OF THE RESEARCH

MPP ENGINEERING QUESTIONNAIRE

Figure 8.2.1. The result of the Engineering questionnaire about SNM key processes MPP niche.

RESULTS OF THE RESEARCH

MPP MANAGEMENT QUESTIONNAIRE

Figure 8.2.2. The result of the Management questionnaire about SNM key processes MPP niche.
8.3 Recommendation

In this section recommendations based on the research findings in conjunction with recommendations for KCI will be described. The recommendations for KCI can be considered as business strategy based on the theoretical framework. It should be noted that the KPQI list and TC checklist were used as basis for the surveys, questionnaires, literature research and discussion with experts and people involved in these projects.

8.3.1 Recommendation for KCI based on SNM

The KPQI list is used to assess the quality of the key processes. The SNM approach doesn’t provide information about how to compare the quality of key processes of two different niche developments. The assessment of the quality was thus based on whether or not the expectations were coupled, actors-network was built and the designers learned from the actors within the network and adjusted their design. Furthermore, this research is based on the following hypothesis:

Good quality of key niche processes leads to successful market introduction of new technologies

In table 8.3 the quality of MPP and SPS are being compared. The quality of each key process determined by the results of the KPQI and questionnaire (see Appendix A) can be compared based on the investment in the technologies by investors, the actors-network configuration (i.e. which technology has a broader network) and amount of test beds.

<table>
<thead>
<tr>
<th>KEY PROCESS</th>
<th>MPP</th>
<th>SPS</th>
<th>Remarks on MPP case study</th>
<th>Remarks on SPS case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quality of the Expectation coupling (investment of investors)</td>
<td>-</td>
<td>+</td>
<td>Low expectation in 2007 because of there is now cheaper options available.</td>
</tr>
<tr>
<td></td>
<td>Question codes: VE.1, VE.2 and VE.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Quality of the Actors-network building (configuration)</td>
<td>-</td>
<td>++</td>
<td>In order to gain more support the actors-network should be broaden. The actors-network is relatively small.</td>
</tr>
<tr>
<td></td>
<td>Question codes: VE.4, LP.1, AN.1 and AN.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Quality of the Learning process (test beds and successful demonstration projects)</td>
<td>-</td>
<td>+</td>
<td>Lessons learned from the past should be documented in order to use it whenever it is needed. MPP needs more successful applications</td>
</tr>
<tr>
<td></td>
<td>Question codes: LP.1, LP.3 and LP.6</td>
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</table>

It can be concluded that the SPS technology has more investors (more resources), broader global network and a lot of successful operating test beds (West Africa and Gulf of Mexico) than MPP.
8.3.2 Recommendation for KCI based on MLP

The KPQI list is also used to assess the regime and landscape whether these external factors had supported the new technology or not. Furthermore, this research is based on the following hypothesis:

*Regime change is required in order to make market introduction of new technologies possible*

With respect to the MPP it can be recommended that the functionalities of the MPP should be reconsidered. The regime has shifted while the oil price increased in favour of SPS and the need to build platforms is very low because all the offshore areas in shallow waters are already scattered with conventional platforms. The offshore industry is moving further from the coasts and in deeper waters. The Marine and Mining legislation will favour SPS as the global energy demand increases and the national governments of Western countries will do anything to avoid oil import dependency.

8.3.3 Recommendation for KCI based on TC

The TC has been used to cover the shortcomings of SNM and MLP. This research is based on the following hypothesis:

*All 5 phases of Technology Commercialization should be taken in consideration in order to achieve a successful market introduction*

In chapter 8 only the added value of the TC have been discussed, which are:

- Mobilizing complementary assets for delivery
- Sustaining phase

*Mobilizing complementary assets for delivery*

Business formula plays an important role in bringing a new technology to the market quickly and effectively. Two things are required according to Jolly (1997) in order to achieve commercial success: The technology’s value needs to become apparent quickly through rapid and broad market penetration (i.e. market size increase) and a method should be found to maximize the appropriation of its benefits. It is impossible to find help without sharing the secrets of the technology.

The challenge is to find a mode to commercialize the technology so as to facilitate wider acceptance (e.g. society or regime) while, at the same time, KCI which is the inventor, should optimize his returns from the investment made. KCI should consider the extent to which the technology is shared and the extent of control over the technology utilization. In other words, KCI should investigate what is best for its product in the range between widely publishing it and allowing all who wish to do whatever they want with and keeping the technology fully proprietary. It can be concluded that for the MPP the answer the best choice will be value-added reseller relationship (see Fig. 8.3) because it is not the only product that KCI tries to launch. By broadening the actors-network interested in the MPP, KCI can choose between licensing and leasing of the MPP concept. The best option should be investigated further by
KCI. In the graph below the instruments of technology commercialization provided by Jolly are displayed. Licensing is a viable alternative when KCI wants to have some control over the technology utilization while it shares the technology with other companies.

Figure 8.3. The instruments of technology commercialization; source Jolly (1997).

Sustaining phase
The KPQI list together with the TC checklist were used to assess the key processes that are required to maintain a client dependency. With respect to the MPP it should be taken into account that the clients using the MPP’s should be persuaded to continue using the MPP for its future marginal fields. Although KCI is not focused on the MPP as other companies do. It requires an aggressive program to persuade actors that don’t share the expectation with KCI. It should be noted that the in-house MPP knowledge can be used also in wind energy platforms. The in-house knowledge and experiences with MPP can be very useful in other market segments as underground gas storage, CO₂ gas storage, LNG storage platforms and great wheel projects. EU legislations (i.e. regime change) should be updated to ensure that these developments can take place without setbacks.
8.3.4 Recommendation for KCI based on the MPP and SPS case studies

The strategy is based on this research which is based on three theoretical concepts which are SNM, MLP and TC. In order to do this research, the key processes of SNM, MLP characteristics and TC characteristics are combined in the KPQI list. This list is used during the research in order to collect the required data by doing literature research and to prepare interviews, to make sure that all facets of the theoretical concepts are incorporated.

Recommendation for Multi Purpose Platform (MPP):

- Broaden actors-network to achieve more MPP users or to persuade actors;
- Promote MPP by more demonstrations and at international exhibitions. However the MPP is a proven technology it still has to compete with cheaper options on the market;
- Use MPP knowledge (i.e. patented structural applications) in other market segments (i.e. great wheel projects and offshore wind energy projects);
- Unlocking of gas reserves in the North Sea will provide more chances for the MPP in the future;
- Results from this research (using KPQI and TC checklist) show that MPP-niche (case 1) has a lower quality of key processes than that of the SPS-niche (case 2).

KCI should believe in the Subsea processing system (SPS) because:

- It is the most potential new technology compared to MPP that can help unlocking the gas reserves in the North sea;
- This technology will be used as tieback to existing and minimum facility platforms. Tieback will prevent that platforms should be sunken or decommissioned onshore;
- EU legislation and high oil prices lead to increasing adventurous independent oil entrepreneurs buying blocks containing small and matured fields in the North sea. These entrepreneurs are more likely to use SPS to unlock gas reserves;
- Results from this research (using KPQI and TC checklist) show that SPS-niche (case 2) has a higher quality of key processes than that of the MPP-niche (case 1).
### List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AUV</td>
<td>Autonomous Underwater Vehicle</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Capital expenditures</td>
</tr>
<tr>
<td>DCP</td>
<td>Dutch continent plate</td>
</tr>
<tr>
<td>EO</td>
<td>Environmental organisation (or group)</td>
</tr>
<tr>
<td>HEI</td>
<td>Higher educational institutes</td>
</tr>
<tr>
<td>HEV</td>
<td>Hybrid emission vehicle</td>
</tr>
<tr>
<td>IOC</td>
<td>International Oil Company</td>
</tr>
<tr>
<td>KCI</td>
<td>Körndorffer contractor international oil and gas engineering consultancy</td>
</tr>
<tr>
<td>KPQI</td>
<td>Key processes quality improvement</td>
</tr>
<tr>
<td>LEV</td>
<td>Low emission vehicle</td>
</tr>
<tr>
<td>MLP</td>
<td>Multi Level Perspective</td>
</tr>
<tr>
<td>MOC</td>
<td>Major Oil Company (Shell, Exxon-Mobile, Chevron, Total)</td>
</tr>
<tr>
<td>NOC</td>
<td>National Oil Company</td>
</tr>
<tr>
<td>NPV</td>
<td>Nett Present Value</td>
</tr>
<tr>
<td>OPEX</td>
<td>Operating expenditures</td>
</tr>
<tr>
<td>ROV</td>
<td>Remote operating vehicle</td>
</tr>
<tr>
<td>SNM</td>
<td>Strategic niche management</td>
</tr>
<tr>
<td>SME</td>
<td>Small Medium Entrepreneurs</td>
</tr>
<tr>
<td>SOC</td>
<td>Small medium enterprise Oil Company</td>
</tr>
<tr>
<td>TC</td>
<td>Technology commercialization approach of V.Jolly</td>
</tr>
<tr>
<td>TUD</td>
<td>Technical university of Delft</td>
</tr>
<tr>
<td>TU/e</td>
<td>Technical university of Eindhoven</td>
</tr>
</tbody>
</table>
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Other publications


  Source: http://www.dw-1.com/


- Kemp, Rotmans, Weterings, van der Horst (2005) Project: From experiments to transitions through strategic niche management;
  Source: http://www.onderzoeksinformatie.nl/nl/oi/nod/onderzoek/OND1318360/

- Commissie Integraal waterbeheer werkgroep 4 Offshore (2002) Stand der techniek offshore productiewater Olie en gaswinning industrie;
  Source: http://www.waterhelpdesk.nl

- KCI Engineering (2007) P and Q block development feasibility reports chevron (confidential)
Internet sources

List of interviewees

KCI MPP Projects 1st and 2nd generation 1997-2000

- Mr. P. Ferrier (General manager)
- Mr. D. Körndorffer (Technical manager)
- Mr. E. van Drunen (Manager projects)
- Mr. W. Caris (Process engineer)
- Mr. M. Lemans (Piping engineer)
- Mr. E. Berkman (Structural engineer)

Offshore technology and subsea technology experts

- Mr. G. Lagers (Offshore technology faculty TUD)
- Mr. J. Preedy (Offshore technology faculty TUD)

Subsea meeting at the company JP Kenny Aberdeen, Scotland

- Mr. P. Ferrier (General manager)
- Mr. H. van Drunen (Manager projects)
- Mr. J. Kwakernaak (Process engineer)
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APPENDIX A-1 M.L.

VRAGENLIJST VOOR KCI MEDEWERKERS DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.

Technologische barrier.

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Verwachtingen

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Leerprocessen

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<td>LP.1</td>
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<td>LP.2</td>
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<td>LP.3</td>
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<td>LP.4</td>
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<tr>
<td>LP.5</td>
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<td></td>
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<tr>
<td>LP.6</td>
<td>Hebt u tijdens het ontwerpen, de tekortkomingen van de conventionele platforms bestudeerd?</td>
<td>☐ ☐ ☐</td>
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**SNM-Processen**

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<tr>
<td>SP.1</td>
<td>Is de in gebruik genomen MPP geselecteerd op basis van een selectie criteria?</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP.2</td>
<td>Vindt u dat u gedurende het project voldoende hebt overlegd met de gebruiker(s)?</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP.3</td>
<td>Vindt u dat de doelen en verwachtingen zijn bijgesteld wanneer het echt noodzakelijk was?</td>
<td>☐ ☐ ☐</td>
<td></td>
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</tr>
<tr>
<td>SP.4</td>
<td>Wist u terwijl u bezig was met het ontwerpen/berekenen etc., wat de voordelen van de MPP zou zijn t.o.v. de conventionele platforms en MOAP?</td>
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**Persoonlijke ontwikkelingen**

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<td>Zou u graag willen meedenken over toepassingen van het MPP concept in andere marktsegmenten?</td>
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<td>Houdt u sindsdien meer rekening met niet technische aspecten die ook een rol kunnen spelen op het product (=proces equipment/structural design)?</td>
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<td></td>
<td></td>
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<tr>
<td>PO.4</td>
<td>Gelooft u dat er in de toekomst meer MP nodig zouden zijn?</td>
<td>☐ ☐ ☐</td>
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</tbody>
</table>
Open vragen:

1. Welke organisaties speelden een grote rol in het actoren netwerk (=organisaties die het MPP project mee hebben gedaan)?

   --

2. Is er sprake geweest van “muddling through” proces waarbij het einddoel niet vast stond?

   --

3. Heeft de MPP geleid tot meerdere implicaties of aanpassing op de conventionele platforms?

   --

4. Moest deze technologie worden afgestemd op de maatschappelijke omgeving? Zo ja, kun je dan een voorbeeld opnoemen?

   --

BEDANKT VOOR UW BIJDRAGE.
APPENDIX A-2 E.B.

VRAGENLIJST VOOR KCI MEDEWERKERS DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.

Technologische barriere.

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<tbody>
<tr>
<td>TB.1</td>
<td>Hebt u tijdens het MPP project advies of technische kennis van een externe expert nodig gehad?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>TB.2</td>
<td>Heeft de wetgeving (zoals milieu eisen) het ontwerpen van de MPP in de kaart gespeeld?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB.3</td>
<td>Hebt u gebruik kunnen of mogen maken van concepten die sterk op de MPP concept leken?</td>
<td></td>
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<tr>
<td>TB.4</td>
<td>Hebt u gebruik gemaakt van patenten?</td>
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Verwachtingen

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<tbody>
<tr>
<td>VE.1</td>
<td>Denkt u dat iedereen binnen de projectgroep in grote lijnen dezelfde verwachtingen had?</td>
<td></td>
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<tr>
<td>VE.2</td>
<td>Was de “scope of work” vanaf de kick-off duidelijk voor u?</td>
<td></td>
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<tr>
<td>VE.3</td>
<td>Is er tijdens het ontwerpen rekening gehouden met milieu organisaties en overige belangen verenigingen die het succes van het project zouden kunnen?</td>
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<tr>
<td>VE.4</td>
<td>Zijn de verwachtingen verhoogd door middel van testen of demonstratie?</td>
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Leerprocessen

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<tbody>
<tr>
<td>LP.1</td>
<td>Is de scope (of het ontwerp) n.a.v. een meeting met de klant/user, gewijzigd?</td>
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<tr>
<td>LP.2</td>
<td>Is de scope gewijzigd vanwege noodzakelijke kosten reductie?</td>
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<tr>
<td>LP.3</td>
<td>Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wetgeving/Eu richtlijnen?</td>
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<tr>
<td>LP.4</td>
<td>Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wensen van andere potentiële klanten/user?</td>
<td></td>
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<tr>
<td>LP.5</td>
<td>Hebt u tijdens het ontwerpen, de tekortkomingen van de MOAP bestudeerd?</td>
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SNM-Processen

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</tr>
<tr>
<td>PO.4</td>
<td>Gelooft u dat er in de toekomst meer MPP nodig zouden zijn?</td>
<td>☐</td>
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</tbody>
</table>
Open vragen:

1. Welke organisaties speelden een grote rol in het actoren netwerk (=organisaties die het MPP project mee hebben gedaan)?

   Lloyds register ivm certificering ontwerp
   RLD ivm certificering helikopter dek

2. Is er sprake geweest van “muddling through” process waarbij het einddoel niet vast stond?

   Nee

3. Heeft de MPP geleid tot meerdere implicaties of aanpassing op de conventionele platforms?

   Nee

4. Moest deze technologie worden afgestemd op de maatschappelijke omgeving? Zo ja, kun je dan een voorbeeld opnoemen?

   Nee

BEDANKT VOOR UW BIJDRAGE.
**APPENDIX A-3 D.K.**

**VRAGENLIJST VOOR HET KCI MANAGEMENT DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.**

### Actoren netwerk.

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<td>ja</td>
<td>nee</td>
<td>Geen antw mogelijk</td>
<td></td>
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<tr>
<td>AN.1</td>
<td>Bestond het actoren netwerk uit een heterogene groep actoren (gebruikers, leveranciers, overheid, publieke en private instellingen)?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>AN.2</td>
<td>Waren er afspraken gemaakt c.q. procedures voorhanden om ervoor te zorgen dat de actoren gecommitteerd bleven gedurende het project?</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>AN.3</td>
<td>Is er rekening gehouden dat bij de overgang van test fase naar implementatie fase de samenstelling van het actoren netwerk zou kunnen veranderen?</td>
<td>☐</td>
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<tr>
<td>AN.4</td>
<td>Waren binnen het actoren netwerk, organisaties c.q. experts die eerder bij &quot;MPP-achtige” projecten betrokken waren?</td>
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### Leerprocessen.

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<td>Geen antw mogelijk</td>
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<tr>
<td>LP.1</td>
<td>Is er tijdens het ontwerpen gekeken naar de mogelijkheden van implementatie van de MPP in andere markt segmenten?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>LP.2</td>
<td>Heeft men tijdens het project contact opgenomen met actoren die voor een technologie-pull konden zorgen (bijv. actoren gespecialiseerd in marktstrategie of die nieuwe concepten/technologieën aan de man brengen)?</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>LP.3</td>
<td>Is er tijdens het ontwerpen een onpartijdige actor aanwezig geweest om &quot;blinde optimisme“ in toom te houden of te voorkomen?</td>
<td>☐</td>
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<tr>
<td>LP.4</td>
<td>Is er tijdens het ontwerpen nagegaan of de overheid een rol had kunnen spelen op het gebied van regelgeving (om het gebruik van MPP’s te stimuleren)?</td>
<td>☐</td>
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### MPP toekomst

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<td>ja</td>
<td>nee</td>
<td>Geen antw mogelijk</td>
<td></td>
</tr>
<tr>
<td>MT.1</td>
<td>Is er rekening gehouden met het feit dat bij overgang van “pioniersmarkt” (wintershall als cliënt) naar grotere markten (overige olie en gas producerende bedrijven) de technologie aangepast (customized) zou moeten worden?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>MT.2</td>
<td>Zijn organisaties die gespecialiseerd zijn in marginale velden benaderd en op de hoogte gebracht van het bestaan van MPP?</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>MT.3</td>
<td>Worden er nog MPP-demonstratie projecten georganiseerd?</td>
<td>☐</td>
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**Z.o.z. 5 open vragen.**
Open vragen:

1. Welke symbolische betekenis (added value) kunt u voor de MPP bedenken? (je moet dan denken aan een slogan zoals “de kracht van de Postbank” of “groene energie”)

   *De MPP’s plaatst Uw bedrijf naar de benodigde hoogte.*

2. Wat is er gedaan om potentiële klanten te identificeren en deze te overhalen om MPP te gebruiken (=huidige business strategy)?

   *Besprekingen en presentaties gehouden.*

3. Welke actoren (naast KCI, Wintershall) speelden een grote rol binnen het netwerk?

   *Regelgeving, dwz de eis voor het verwijderen van platforms.*

4. Was het MPP project door de klant of door KCI management “gemanaged”?

   *Door de KCI management (clients’ representative).*

5. Wat kun je vertellen over de concurrentie ondervonden van de MOAP? (bijv. Waarom volgens u bepaalde olie bedrijven juist voor de MOAP hebben gekozen?)

   *De MOAB was uit eindelijk voor de operator Perenco geplaatst in de Noordzee. Dit ontwerp komt van Overdick vandaan welke betere contacten hebben bij deze operator. Dit soort opdrachten moet toch gegund worden.*

**BEDANKT VOOR UW BIJDRAGE.**
APPENDIX A-4 P.F.

VRAGENLIJST VOOR KCI MEDEWERKERS DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.

Technologische barrière.

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<tr>
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<table>
<thead>
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<th>TB.2</th>
<th>Heeft de wetgeving (zoals milieu eisen) het ontwerpen van de MPP in de kaart gespeeld?</th>
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<th>Denkt u dat iedereen binnen de projectgroep in grote lijnen dezelfde verwachtingen had?</th>
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<th>VE.3</th>
<th>Is er tijdens het ontwerpen rekening gehouden met milieu organisaties en overige belangen verenigingen die het succes van het project zouden kunnen?</th>
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<td>2 1 - Geen antwoord mogelijk</td>
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<td>ja</td>
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<thead>
<tr>
<th>VE.4</th>
<th>Zijn de verwachtingen verhoogd door middel van testen of demonstratie?</th>
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<tbody>
<tr>
<td></td>
<td>2 1 - Geen antwoord mogelijk</td>
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Leerprocessen

<table>
<thead>
<tr>
<th>LP.1</th>
<th>Is de scope (of het ontwerp) n.a.v. een meeting met de klant/user, gewijzigd?</th>
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<td>2 1 - Geen antwoord mogelijk</td>
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<thead>
<tr>
<th>LP.2</th>
<th>Is de scope gewijzigd vanwege noodzakelijke kosten reductie?</th>
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<td>2 1 - Geen antwoord mogelijk</td>
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<thead>
<tr>
<th>LP.3</th>
<th>Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wetgeving/Eu richtlijnen?</th>
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<tr>
<td></td>
<td>2 1 - Geen antwoord mogelijk</td>
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<thead>
<tr>
<th>LP.4</th>
<th>Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wensen van andere potentiële klanten/user?</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2 1 - Geen antwoord mogelijk</td>
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<td>ja</td>
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<thead>
<tr>
<th>LP.5</th>
<th>Hebt u tijdens het ontwerpen, de tekortkomingen van de MOAP bestudeerd?</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2 1 - Geen antwoord mogelijk</td>
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<td>ja</td>
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</table>
**LP.6** Hebt u tijdens het ontwerpen, de tekortkomingen van de conventionele platforms bestudeerd?  

**SNM-Processen**

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<tr>
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<td>ja</td>
<td>nee</td>
<td>Geen antwoord mogelijk</td>
</tr>
<tr>
<td><strong>SP.1</strong> Is de in gebruik genomen MPP geselecteerd op basis van een selectie criteria?</td>
<td></td>
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</tr>
<tr>
<td><strong>SP.2</strong> Vindt u dat u gedurende het project voldoende hebt overlegd met de gebruiker(s)?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>SP.3</strong> Vindt u dat de doelen en verwachtingen zijn bijgesteld wanneer het echt noodzakelijk was?</td>
<td></td>
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</tr>
<tr>
<td><strong>SP.4</strong> Wist u terwijl u bezig was met het ontwerpen/berekenen etc., wat de voordelen van de MPP zouden zijn t.o.v. de conventionele platforms en MOAP?</td>
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**Persoonlijke ontwikkelingen**

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<td>ja</td>
<td>nee</td>
<td>Geen antwoord mogelijk</td>
</tr>
<tr>
<td><strong>PO.1</strong> Zou u graag willen meedenken over toepassingen van het MPP concept in andere marktsegmenten?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PO.2</strong> Houdt u sindsdien meer rekening met niet technische aspecten die ook een rol kunnen spelen op het product (=process equipment/structural design)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PO.3</strong> Denkt u dat de MPP verbeterd kan worden zodat het met bijv. subsea completions kan concurreren?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PO.4</strong> Gelooft u dat er in de toekomst meer MPP nodig zouden zijn?</td>
<td></td>
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</tbody>
</table>
Open vragen:

1. Welke organisaties speelden een grote rol in het actoren netwerk (=organisaties die het MPP project mee hebben gedaan)?
   
   *Clyde Petroleum (opdrachtgever)*
   *KCI (ontwerpers)*
   *Hollandia & Genius Vos (fabricators)*
   *HOC (marine operations ➔ bestaan niet meer)*
   *Marin (model testen)*
   *IHC (jacking systemen)*
   *SPT (pompen)*

2. Is er sprake geweest van “muddling through” process waarbij het einddoel niet vast stond?
   
   *Er moesten vanaf het begin 3 platformen komen met een vooraf bepaalde target date voor first gas*

3. Heeft de MPP geleid tot meerdere implicaties of aanpassing op de conventionele platforms?
   
   *Ik denk niet zo zeer aanpassingen op de conventionele platforms als wel aanpassingen op de volgende generaties MPP: makkelijkere fabricage, installatie, dieper water, hogere dekbelasting etc.*

4. Moest deze technologie worden afgestemd op de maatschappelijke omgeving? Zo ja, kun je dan een voorbeeld opnoemen?

   *Nee*

BEDANKT VOOR UW BIJDRAGE.
## APPENDIX A-5 P.F.

**VRAGENLIJST VOOR HET KCI MANAGEMENT DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.**

### Actoren netwerk.

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<tbody>
<tr>
<td>AN.1</td>
<td>Bestond het actoren netwerk uit een heterogene groep actoren (gebruikers, leveranciers, overheid, publieke en private instellingen)?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>AN.2</td>
<td>Waren er afspraken gemaakt c.q. procedures voorhanden om ervoor te zorgen dat de actoren gecommitteerd bleven gedurende het project?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>AN.3</td>
<td>Is er rekening gehouden dat bij de overgang van test fase naar implementatie fase de samenstelling van het actoren netwerk zou kunnen veranderen?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>AN.4</td>
<td>Waren binnen het actoren netwerk, organisaties c.q. experts die eerder bij “MPP-achtige” projecten betrokken waren?</td>
<td>ja</td>
<td>nee</td>
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</table>

### Leerprocessen.

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<tbody>
<tr>
<td>LP.1</td>
<td>Is er tijdens het ontwerpen gekeken naar de mogelijkheden van implementatie van de MPP in andere markt segmenten?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>LP.2</td>
<td>Heeft men tijdens het project contact opgenomen met actoren die voor een technologie-pull konden zorgen (bijv. actoren gespecialiseerd in marktstrategie of die nieuwe concepten/technologieën aan de man brengen)?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>LP.3</td>
<td>Is er tijdens het ontwerpen een onpartijdige actor aanwezig geweest om “blinde optimisme” in toom te houden of te voorkomen?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>LP.4</td>
<td>Is er tijdens het ontwerpen nagegaan of de overheid een rol had kunnen spelen op het gebied van regelgeving (om het gebruik van MPP’s te stimuleren)?</td>
<td>ja</td>
<td>nee</td>
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### MPP toekomst.

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<tbody>
<tr>
<td>MT.1</td>
<td>Is er rekening gehouden met het feit dat bij overgang van “pioniers markt” (wintershall als cliënt) naar grotere markten (overige olie en gas producerende bedrijven) de technologie aangepast (customized) zou moeten worden?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>MT.2</td>
<td>Zijn organisaties die gespecialiseerd zijn in marginale velden benaderd en op de hoogte gebracht van het bestaan van MPP?</td>
<td>ja</td>
<td>nee</td>
</tr>
<tr>
<td>MT.3</td>
<td>Worden er nog MPP-demonstratie projecten georganiseerd?</td>
<td>ja</td>
<td>nee</td>
</tr>
</tbody>
</table>

*Z.o.z. 5 open vragen.*
Open vragen:

1. Welke symbolische betekenis (added value) kunt u voor de MPP bedenken? (je moet dan denken aan een slogan zoals “de kracht van de Postbank” of “groene energie”)

   "Veld leeg? Dan verplaatsen we ‘m toch gewoon!"

2. Wat is er gedaan om potentiële klanten te identificeren en deze te overhalen om MPP te gebruiken (=huidige business strategy)?

   Gekeken welke operators zich bezig hielden/houden met marginale velden en met een minimum aan topside facilities. Deze dan benaderen met het MPP concept en dat van daaruit verder “marketen”.

3. Welke actoren (naast KCI, Wintershall) speelden een grote rol binnen het netwerk?

   - Hollandia & Genius Vos (fabricators)
   - HOC (marine operations bestaan niet meer)
   - Marin (model testen)
   - IHC (jacking systemen)

4. Was het MPP project door de klant of door KCI management “gemanaged”?

   KCI was verantwoordelijk voor Engineering en Design, constructie begeleiding en installatie management

5. Wat kun je vertellen over de concurrentie ondervonden van de MOAP? (bijv. Waarom volgens u bepaalde olie bedrijven juist voor de MOAP hebben gekozen?)

   In het prille begin heeft KCI samengewerkt met de mensen die de MOAP hebben ontwikkeld (Overdick). Ten tijde van de 1e generatie MPP bestond de MOAP nog niet. Momenteel zijn er 2 of 3 MOAP’s wereldwijd geïnstalleerd. De meest recente mobiele offshore productie installaties zijn MOAP’s. Ik denk dat de reden waarom zij recentelijk succesvoller zijn dan KCI is, dat de MOAP Overdick’s belangrijkste product is en dit meer “vermarkten” dan dat KCI dat momenteel doet.

BEDANKT VOOR UW BIJDRAGE.
## APPENDIX A-6 W.C.

**VRAGENLIJST VOOR KCI MEDEWERKERS DIE AAN HET MPP PROJECT HEBBEN MEEGEWERKT.**

### Technologische barrière.

| TB.1 | Hebt u tijdens het MPP project advies of technische kennis van een externe expert nodig gehad? – *For process simulations (by Keuken & Konings)* | ☐ | ☐ | ☐ |
| TB.2 | Heeft de wetgeving (zoals milieu eisen) het ontwerpen van de MPP in de kaart / positieve rol gespeeld? – *Not that I know from a process view* | ☐ | ☐ | ☐ |
| TB.3 | Hebt u gebruik kunnen of mogen maken van concepten die sterk op de MPP concept leken? – *Process installation was basically a copy of an existing satellite platform with a fixed structure.* | ☐ | ☐ | ☐ |
| TB.4 | Hebt u gebruik gemaakt van patenten? - *Not for the process system* | ☐ | ☐ | ☐ |

### Verwachtingen

| VE.1 | Denkt u dat iedereen binnen de projectgroep in grote lijnen dezelfde verwachtingen had – m.b.t. werkzaamheden eind resultaat? | ☐ | ☐ | ☐ |
| VE.2 | Was de “scope or work” vanaf de kick-off duidelijk voor u? – *Did not attend this meeting* | ☐ | ☐ | ☐ |
| VE.3 | Is er tijdens het ontwerpen rekening gehouden met milieu organisaties en overige belangen verenigingen die het succes van het project zouden kunnen? - *Not that I know from a process view* | ☐ | ☐ | ☐ |
| VE.4 | Zijn de verwachtingen verhoogd door middel van testen of demonstratie? *Not that I know from a process view* | ☐ | ☐ | ☐ |

### Leerprocessen

| LP.1 | Is de scope (of het ontwerp) n.a.v. een meeting met de klant/user, gewijzigd? – *debottlenecking study for P2NE MPP / Name change for one of the MPP’s P2NE/P2SE/P6S, …* | ☐ | ☐ | ☐ |
| LP.2 | Is de scope gewijzigd vanwege noodzakelijke kosten reductie? - *Not that I know from a process view* | ☐ | ☐ | ☐ |
| LP.3 | Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wetgeving/Eu richtlijnen? *Not that I know from a process view* | ☐ | ☐ | ☐ |
| LP.4 | Zijn er wijzigingen in het ontwerp ingevoerd vanwege de wensen van andere potentiële klanten/user? *Not that I know from a process view* | ☐ ☐ ☐ |
| LP.5 | Hebt u tijdens het ontwerpen, de tekortkomingen van de MOAP bestudeerd? | ☐ ☐ ☐ |
| LP.6 | Hebt u tijdens het ontwerpen, de tekortkomingen van de conventionele platforms bestudeerd? *- On MPP storage tanks and skimmers can be integrated in pontoons.* | ☐ ☐ ☐ |

**SNM-Processen**

| SP.1 | Is de in gebruik genomen MPP geselecteerd op basis van een selectie criteria? *Not that I know from a process view* | ☐ ☐ ☐ |
| SP.2 | Vindt u dat u gedurende het project voldoende hebt overlegd met de gebruiker(s)? *– Not in position for meetings with cliënt at that time* | ☐ ☐ ☐ |
| SP.3 | Vindt u dat de doelen en verwachtingen zijn bijgesteld wanneer het echt noodzakelijk was? | ☐ ☐ ☐ |
| SP.4 | Wist u terwijl u bezig was met het ontwerpen/berekenen etc., wat de voordelen van de MPP zouden zijn t.o.v. de conventionele platforms en MOAP? | ☐ ☐ ☐ |

**Persoonlijke ontwikkelingen**

| PO.1 | Zou u graag willen meedenken over toepassingen van het MPP concept in andere marktsegmenten? | ☐ ☐ ☐ |
| PO.2 | Houdt u sindsdien meer rekening met niet technische aspecten die ook een rol kunnen spelen op het product (=process equipment/structural design)? | ☐ ☐ ☐ |
| PO.3 | Denkt u dat de MPP verbeterd kan worden zodat het met bijv. subsea completions kan concurreren? *Depends on water depth and well work over requirements, operating conditions, cleanliness of produced fluids* | ☐ ☐ ☐ |
| PO.4 | Gelooft u dat er in de toekomst meer MPP nodig zouden zijn? | ☐ ☐ ☐ |

**Open vragen:**
1. Welke organisaties speelden een grote rol in het actoren netwerk (=organisaties die het MPP project mee hebben gedaan)?

*O.a. Jacking systeem (IHC?)*

2. Is er sprake geweest van “muddling through” process waarbij het einddoel niet vast stond?

*Nee*

3. Heeft de MPP geleid tot meerdere implicaties of aanpassing op de conventionele platforms?

*Geen grote implicaties. Glycol toevoer vanuit storage tanks in lager gelegen pontons dient gepompt te worden vanuit deze tanks naar een zogenaamde dagtank van waaruit het verder verpompt wordt. Op conventionele is deze dagtank niet nodig.*

4. Moest deze technologie worden afgestemd op de maatschappelijke omgeving? Zo ja, kun je dan een voorbeeld opnoemen?

*Niet voor process*

**BEDANKT VOOR UW BIJDRAGE.**
I've 12 questions about Subsea hardware and subsea development in the future. I hope you can help me out and I will appreciate that very much. Here are the questions which are related to subsea technology, innovation and increasing market size:

1. What are the top 3 market drivers of subsea hardware? (What is causing the technology pull?)
   - Large Deepwater Fields developed with FPSO plus subsea.
   - Large numbers of small fields with a few well tie-backs.
   - The very good economics using subsea.

2. What else (e.g. financial support? Or energy demand? Or good expectation) is supporting the subsea application?
   All oil developments are advantaged by the $60 oil price. This make many field regarded as uneconomic now possible.
   - The oil price is driven by the increased World demand for energy.
   - Look at the DOUGLAS WESTWOOD website. www.dw-1.com You must sign in then you can get to his latest papers / presentations on the world energy position. Information in his slides will be of interest

3. What is/are the reason(s) for this optimistic feeling about the future subsea technology growth?
   - See Douglas Westwood presentation.

4. Do you expect that societal groups will hinder this emerging subsea market? (Could Greenpeace for example hinder the subsea oil and gas recovery)
   No.

5. Besides increasing of energy demand and high prices, did national governments also contributed to this new frontier technology (deeper waters and remote areas)?
   Subsea activities are well supported by governments. I.e. in UK the is a group supported by the government called UK Subsea whose aim is to assist the industry. In Norway DEMO 2000 has a similar aim.

6. Could you please say something about how the higher educational sector in the Netherlands and UK helps to decrease the shortage of skilled qualified personnel?
No, in fact in the UK and other areas there is a big oil and gas engineering skill shortage. Students prefer to do “soft” degrees like media studies than real engineering. Also students are fed a poor image of the oil and gas industries by the media and it is not considered a “Cool” or “sexy” industry.

7. What is/are the latest technological groundbreaking breakthrough(s) related to the subsea hardware?

   Subsea Processing. This is not a new idea but is being considered more – its time is now. See Douglas Westwood web site for more info – he call this a “game Changer”.

8. Can you please say something about the subsea technological progress of the last 10 years that made hydro carbon recovery in 3000 m and deeper water feasible?

   Major activities in West Africa with many big fields with a lot of Subsea equipment. I.e. Dalia field with more than 60 subsea wells.

9. Do you have or know websites that can give me some facts and figures related to the emerging subsea market and subsea hardware applications (UK, NL or global)?

   www.offshore-technology.com

10. Which companies and oil-related organizations are globally the major players and/or users of the subsea technology?

    BP. Shell. Total. Chevron Texaco. Statoil. Hydro plus nearly all the smaller oil companies. See projects in the offshore-technology web site.

11. Can you say something about how experiments or niche development are taking place efficiently to make this subsea technology progress possible?

    Reduced costs of subsea intervention. With ROVs and the emerging AUVs.

12. Can you name (or provide websites) some potential subsea development and projects for in the future.

    Look at Statoil, Hydro and Total websites
## APPENDIX B-2 G.L.

### VRAGENLIJST VOOR OFFSHORE TECHNOLOGIE FACULTEIT TU DELFT

**Actoren netwerk.**

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<tr>
<td><strong>AC.1</strong></td>
<td>Heeft de faculteit regelmatig contact met potentiële gebruikers?</td>
<td>X</td>
</tr>
<tr>
<td><strong>AC.2</strong></td>
<td>Heeft de faculteit regelmatig contact met het bedrijfsleven?</td>
<td>X</td>
</tr>
<tr>
<td><strong>AC.3</strong></td>
<td>Bent u betrokken geweest bij offshore projecten op de Noord zee?</td>
<td>X</td>
</tr>
<tr>
<td><strong>AC.4</strong></td>
<td>Bent u betrokken geweest bij markt introductie van nieuwe technologische concepten?</td>
<td>X</td>
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**Leerprocessen tijdens het ontwerpen**

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<tr>
<td><strong>LP.1</strong></td>
<td>Is er tijdens het ontwerpen gekeken naar de mogelijkheden van implementatie van de nieuwe technologische concepten in andere markt segmenten?</td>
<td>□</td>
</tr>
<tr>
<td><strong>LP.2</strong></td>
<td>Is er tijdens het ontwerpen gekeken naar actoren die voor een technologie pull konden zorgen (actoren gespecialiseerd in marktstrategie)?</td>
<td>□</td>
</tr>
<tr>
<td><strong>LP.3</strong></td>
<td>Is er tijdens het ontwerpen een onpartijdige acteur aanwezig geweest om blinde optimisme te voorkomen?</td>
<td>□</td>
</tr>
<tr>
<td><strong>LP.4</strong></td>
<td>Is er tijdens het ontwerpen nagegaan of de overheid een rol had kunnen spelen op het gebied van regelgeving?</td>
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**Offshore in de toekomst**

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<tr>
<td><strong>OT.1</strong></td>
<td>Is er rekening gehouden met het feit dat bij overgang van pioniers markt naar grotere markten de technologie aangepast moet worden?</td>
<td>X</td>
</tr>
<tr>
<td><strong>OT.2</strong></td>
<td>Zijn organisaties die gespecialiseerd zijn in marginale olie en gasvelden benaderd en op de hoogte gebracht van het bestaan van nieuwe technologieën ontwikkeld door TU Delft?</td>
<td>□</td>
</tr>
<tr>
<td><strong>OT.3</strong></td>
<td>Worden er demonstratiet projecten georganiseerd om de nieuwste uitvindingen te promoten?</td>
<td>X</td>
</tr>
</tbody>
</table>
Open vragen:

1. Wat is de bijdrage van TU Delft faculteit offshore technologie aan de Nederlandse olie en gas industrie?

   Vooral het opleveren van afgestudeerden met een brede kennis op offshore olie en gas gebied.

2. Wat is de bijdrage van TU Delft faculteit offshore technologie aan de olie en gas industrie wereldwijd?

   Zie 1, wij maken geen onderscheid tussen NL en de rest van de wereld.

3. Hoe ziet volgens u de toekomst van de offshore industrie uit?


4. Wordt er op de faculteit aandacht geschonken aan LNG-transport en -opslag? Zo ja, wat is de bijdrage tot nu toe van de faculteit?

   Meerdere afstudeerders hebben aspecten van de problematiek bestudeerd. Wij hebben binnen offshore geen colleges of andere kennisoverdracht op dit gebied.

5. Worden nieuwe technologieën en/of concepten waarbij TU Delft betrokken is voornamelijk geïnitieerd en gemanaged door experts van TU Delft, door het bedrijfsleven of is er sprake van een samenwerkingsverband?

   Vooral door eigen medewerkers. Denk aan het Ampelmann project o.l.v. dr.ir. J. van der Tempel

6. Wat voor advies geeft u namens TU Delft aan ingenieurbureaus die actief zijn op het gebied van offshore m.b.t. innovatieprocessen en samenwerking met kennisinstellingen?

   Namens de TUD is lastig, dus volgende is mijn advies. Stel het bureau open voor afstudeerders en geef ze iets uit te zoeken, wat het bureau interessant vindt maar waaraan het niet toekomt. Zorg wel voor goede begeleiding. Probeer op deze wijze zowel direct aan innovatie te doen via afstudeer projecten en goede mensen binnen te halen.

   George Lagers
APPENDIX C

RESULTS OF THE RESEARCH

MPP ENGINEERING QUESTIONNAIRE

QUESTION CODE

| YES | NO | Neutral |

RESULTS OF THE RESEARCH

MPP MANAGEMENT QUESTIONNAIRE

QUESTION CODE

| YES | NO | Neutral |
APPENDIX D

Oil recovery in the future
As the amount of large oil fields (more barrel oil are being burned than discovered) is declining several alternative niche experiments are taking place within the traditional regime. These experiments are created to maintain the fossil fuel regime or to extend the world energy dependency on fossil fuel. In this chapter three most promising innovations within this fossil fuel regime will be discussed. The most promising innovations besides subsea processing systems are:

1. LNG supply chain
2. Tar sand

LNG Supply chain
The natural gas as future feedstock is more difficult then oil to transfer from the source to the refinery and consumer. Oil is in liquid phase that can be transferred from offshore to on shore via pipelines by using pumps. When the oil is recovered onshore it is also transferred via pipeline to the refinery or oil terminal. When the oil is recovered at a large distance from shore, at a marginal field or far from the pipeline infrastructure it will be pumped into FPSO and brought onshore by oil tankers. An FPSO Floating Production, Storage and Offloading Vessel is a special ship which is equipped with oil and gas treatment equipment and with a significant storage capacity on board.

The natural gas however can be transferred by compressors via pipelines to shore but not into large ships in gas. Natural gas can be converted into liquid and transported but the conditions for maintaining it in the liquid state requires special facilities which are very expensive. Furthermore, the economics of conversion into liquid are also too costly to make this type of feedstock compete
with oil so far\textsuperscript{119}. It is economically not feasible to transport gas by ships without an additional cryogenic process. Nevertheless, the Gasunie and Vopak have performed a feasibility study\textsuperscript{120} for the development of a LNG import and terminal at the Maasvlakte of Rotterdam. The terminal must produce 16 billion cubic meter natural gas per year in order to deliver sufficient natural gas and to be competitive with other terminals. The following items should be studied:

1. The storage safety and safeguarding
2. Facility for LNG ships
3. Facility to condensate LNG into natural gas
4. Ensure continuous injection of natural into the existing infrastructure of West Europe

In the figure below a LNG carrier can be depicted.

![LNG carrier](http://www.yokogawa.com/ia/industries/lng/ia-lng-lngcarrier-en.htm)

Figure. D.2 LNG carrier yokogawa


\textsuperscript{120} http://www.oranjewoud.nl/index.cfm/site/Oranjewoud/pageid
Deep sea subsea and FPSO

Figure. D.3 Deep sea technology
source: http://www.scandoil.com/moxie/moxiepix/t714.jpg
Tar sand
Tar sands are naturally-occurring geological formations found in, for example, Canada (Alberta). Such sands have potential for yielding large amounts of petroleum. Tar sands are porous sands generally containing substantial amounts of clay and filled with heavy, relatively solid asphaltic hydrocarbons. Most of these tar-like bituminous materials are residues remaining in reservoir rocks after lighter (lower molecular weight) crude oils have escaped. The largest of the world's tar sand deposits occur in northern Alberta along the Athabasca River. Tar sand layers in this area may be more than 60 meters thick and lie near the surface over a total area of about 50 000 km. They are estimated to contain a potential yield in excess of 1.6 trillion barrels of oil\textsuperscript{121}. Many oil companies are interested in this oil production site when the oil price is high enough to make exploitation of this site profitable. Production from this source is around 1 million barrel per day (bbl) as of 2006, and is expected to build up to 3.2 million bbl per day by 2015. New technology has drastically reduced the cost of extracting oil from this source\textsuperscript{122}. However radical innovation is still required to exploit more of these tar sand fields.

Figure.D.4.Tar sands

\textsuperscript{121} http://www.patentstorm.us/patents/6251290-description.html

\textsuperscript{122} http://en.wikipedia.org/wiki/Peak_oil
APPENDIX E

History of Subsea engineering

Subsea engineering has developed and evolved rapidly over the past 30 years since the subsea development of the Argyll development by Hamilton Brothers. We have reached the point where we have the ability to install subsea completions in water depths in excess of 3000m. As importantly, we have extended the lateral spread of field developments to beyond 50km. We are now used to the development of subsea deepwater fields with a complement of 70 wells, offshore Africa.

To assist these and future subsea developments, we now have at our disposal subsea multiphase pumps, multiphase flow meters (which obviate the need for production test lines), and now, finally, an all-electric subsea control system, Cameron having announced the availability of its groundbreaking CameronDC at this year's OTC in Houston (OE June). We can now think well beyond 200km for future tie backs. We can now save millions on the procurement, installation and repair of unwieldy composite hydraulic umbilicals, which have grown to the point of disbelief on the big West African offshore developments.

First use of hydraulic power for subsea actuators came with the introduction of the subsea BOP in 1961. The BOP hydraulic system, including the quick disconnect system, was designed and manufactured by the legendary Paul C Koomey. Over the years that direct hydraulic control system has been extrapolated to produce the multiplexed electro-hydraulic control system in common use today. Now at last we have the new Cameron DC electric system, and there is no doubt that others will soon follow suit.

Various sources indicate that McEvoy was the first company to propose true subsea completions in 1958. The first subsea BOP was developed in 1961, and that same year Shell announced the first subsea well completion in the Gulf of Mexico. That well was fittingly located on Cameron block 192 in 16m water depth. From small acorns do great oaks grow! At about the same time some 20 subsea completed wells were being installed offshore California as tiebacks to the Conception field platform.

The North Sea's first subsea completion was installed in the Norwegian sector, on Phillips' Ekofisk field as a tieback to a jackup drilling rig. In the UK sector, Chevron installed the first subsea completion on the Ninian field as a tieback to Ninian Central platform. This was essentially a prototype/development project.

The industry had to wait until Hamilton Brothers used true subsea technology to develop the Argyll field in 1975 with a multiwell subsea development tied back to the first FPS, the Transworld 58 (pictured on OE's cover in January 1975). The entire development was masterminded by Jim Johnson, a driller from Sedco. He was a giant of a man with a devastating sense of humour and great vision. I was privileged to work with him.

APPENDIX F

PROS AND CONS SUBSEA

"Subsea tiebacks, which link new discoveries to existing infrastructure, are now becoming viable."

Maerli says that subsea tiebacks provide a number of important benefits in the development of oil and gas fields. Because much of the infrastructure is already in place, projects can be fast tracked and brought into production much more quickly. There can be flexible and phased developments in certain fields, which are beneficial for small/marginal developments.

In addition, as production capacity becomes available on existing installations and infrastructure, subsea tiebacks are very important in maintaining production levels. Statoil has a production ambition of 55% recovery from subsea wells.

Many small discoveries have been made on the Norwegian Continental Shelf (NCS) over the years that were not considered economic. These are now candidates for development using subsea tiebacks, as the infrastructure is developing, production capacity is becoming available and production from the large fields is beginning to plateau.

Obviously, as oil prices increase, the economics of smaller developments become more attractive, and as more areas of the world are developed and matured, the number of subsea tiebacks worldwide is expected to grow significantly. The advent of subsea processing has now made subsea tiebacks even more attractive, as this can alleviate flow assurance and interfacing difficulties with existing production facilities.

Exxon's Profit Will Be Hard to Top

Record $39.5 Billion Net Masks Industry Challenge: Higher Costs, Lower Prices

By RUSSELL GOLD, BENOÎT FAUCON and ANGEL GONZALEZ

February 2, 2007; Page A3

Exxon Mobil Corp., after posting the largest annual profit in U.S. corporate history, now faces another big challenge: what to do for an encore.

The world's largest publicly traded energy producer and the largest public U.S. company by market value racked up a $39.5 billion full-year profit -- about $108 million a day, and the latest in a string of record Exxon profit reports. But its fourth-quarter net income dropped 4% from a year earlier, underscoring the industrywide challenges that rising costs and lower commodity prices present to matching previous fat profit reports.

Royal Dutch Shell PLC, the fourth-largest publicly traded oil company, saw its fourth-quarter profit rise 21% and posted $25.44 billion in full-year profit. But it continues to face supply challenges three years after slashing its tally of oil and natural-gas reserves due to an accounting scandal.

For Exxon, Wall Street is hoping its reach and breadth will help it continue to draw out new supplies of oil and natural gas and eke out fatter margins than its rivals on its so-called downstream business, which makes and sells refined products like gasoline. So even though Exxon might not break its own record in 2007, analysts said, the traditional foundation of its profitability -- skillful and budget-wise execution of hugely complex and expensive energy projects -- will help the company continue to churn out income and cash.

Investment bank Friedman, Billings, Ramsey & Co. projects the Irving, Texas-based company's net income to reach $35.9 billion in 2007 -- a drop from last year's levels, but still higher than 2005, according to a research note. "The focus is the same, the strategy is the same and therefore we expect the story to be the same," says Lanny Pendill, senior energy analyst for broker Edward Jones.

Exxon, Shell and their oil peers face a tough future. Many untapped oil and gas reserves are held by nations that don't want to let in Western oil companies. The companies also face industrywide cost inflation and pressure by governments seeking more for themselves in production agreements.

Cuts mandated by the Organization of Petroleum Exporting Countries also could have an effect on production during 2007. "We produce from several OPEC member countries," said Exxon Investor Relations Vice President Henry Hubble. "We really don't know exactly what those impacts would be."

Also, the future of some significant Exxon projects is still up in the air. The company has to successfully conclude negotiations for the transformation of the Exxon-operated Cerro Negro project -- which each day processes 120,000 barrels of heavy crude oil into synthetic crude -- into a joint-venture controlled by the Venezuelan government. Venezuelan officials said yesterday that its new joint ventures will become effective May 1, and if the foreign operators disagree with the terms, the government will take over the projects.

Even in this environment, Exxon is positioned to increase oil-and-gas production faster than its peers, an important measure of future profits. The company finished the year with a 4.2% increase in its combined oil and gas production, compared with a 1% drop for Shell. Other oil companies have yet to report.
Exxon's production growth is the result of "long-term planning and execution," says Daniel Barcelo, an energy analyst at Bank of America. He expects Exxon to raise its production at an annual rate of 4.5% from 2005 through 2010, well ahead of its peers.

Exxon reported fourth-quarter net income of $10.25 billion, or $1.76 a share, compared with $10.71 billion, or $1.71 a share, a year earlier. The latest quarter included a tax-related gain of $410 million. The fourth quarter of 2005 included a litigation-related gain of $390 million.

For the year, Exxon's net income was up 9.3%. Exxon distributed $32.6 billion to shareholders in 2006 through dividends and share purchases, up 41% from 2005.

The company's fourth-quarter production of oil and natural gas increased by 6%, reflecting new output from major investments like Sakhalin-1 in Russia's far east. This contrasts with Shell's treatment on Sakhalin Island. Pressure from Moscow forced it to dilute its stake in the massive Russian Sakhalin-2 project, which Shell said yesterday could cut some 1.1 billion barrels of oil equivalent off its fully consolidated reserves in 2007.

Shell also said Nigeria's unrest was hurting its production. The company said it expects overall oil-and-gas production in 2007 to be in the range of 3.3 million to 3.5 million barrels of oil equivalent a day "in the event that Nigerian volumes remain deferred for the rest of the year." Shell's average production in 2006 was 3.47 million barrels of oil equivalent a day.

Still, the company pleased investors by raising fourth-quarter production. Production of oil and natural gas, the cornerstone of the company's earnings, was 3.65 million barrels of oil equivalent a day in the fourth quarter, up from 3.50 million in the same period of 2005. For the year, it produced 3.47 million barrels of oil equivalent daily, down 1.3% from a year earlier.

Shell said its reserves replacement ratio for group companies and equity-accounted entities in 2006 is expected to be 150% including oil sands, a figure it said compares with a ratio of 78% in 2005. The ratio provides an indication of an oil company's future growth. Shell Chief Financial Officer Peter Voser said the company added reserves of two billion barrels of oil equivalent in 2006, largely from its Canadian oil-sands reserves and some reserves from its Qatar gas-to-liquids, or GTL, project on which it gave the go-ahead last year.

Mr. Voser said oil sands had been booked as mining reserves under existing Securities and Exchange Commission rules, but the SEC had agreed to let it record GTL resources as hydrocarbon reserves.

Fourth-quarter 2006 net income was $5.28 billion, or 83 cents a share, compared with $4.37 billion, or 66 cents a share, posted for the fourth quarter of 2005. The quarterly results reflected a net gain of $515 million related to asset divestitures and the valuation of natural-gas contracts. Shell's numbers conform to international financial reporting standards, which differ from U.S. generally accepted accounting principles.

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URL for this article:
http://www.uic.edu/classes/actg/actg516rtr/Readings/Earnings-Announcement/Exxon's%20Profit%20Will%20Be%20Hard%20to%20Top.htm

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**APPENDIX H**

**Milieudefensie daagt Shell uit; April 2007**

19 Apr 07, 08:13

AMSTERDAM (ANP-AFX) - Milieudefensie wil multinational Shell met een mediacampagne overhalen een milieuvriendelijker koers te gaan volgen. Via advertenties donderdag in de Volkskrant en de Pers vraagt Milieudefensie aandacht voor de problemen die Shell met de oliewinning veroorzaakt in Nigeria. Ook zal de milieugroepering gebruik maken van spotjes op de radio. Het initiatief van de milieugroepering is een persiflage op de manier waarop Shell volgens de milieugroepering probeert een milieuvriendelijk imago te krijgen. “Shell profileert zich als een creatieve en duurzame oplosser van energieproblemen. Wij willen Shell aanmoedigen dit in daden om te zetten door haar problemen in Nigeria op te lossen”, aldus Anne van Schaik. Volgens Milieudefensie zijn olielekkages en het affakkelen van gas al jaren grote problemen voor mens en milieu in de Nigrerdelta. “Mensen hebben gezondheidsklachten, drinkwater en landbouwgronden zijn vervuild, tropische bossen worden verwoest. Shell is de grootste buitenlandse oliemaatschappij in Nigeria. Toch blijft de multinational het oplossen van deze problemen uitstellen.” De mediacampagne van Milieudefensie duurt tot 15 mei, de dag van de aandeelhoudersvergadering van Shell.

Source: http://www.dft.nl/bedrijven/royal_dutch_shell_a/1499794/Milieudefensie_daagt_Shell_uu.html

**Greenpeace’s foolish Atlantic Campaign; October 1997**

The well known environmental activist organization Greenpeace appears to have had a problem attracting publicity for its latest campaign, a program based on an ill-conceived report, "Putting the Lid on Fossil Fuels." The Greenpeace-originated report has as its premise that to prevent global warming, the use of fossil fuels must be phased out worldwide. Thus, in Greenpeace logic, exploration for petroleum should be halted, since known reserves are four times as much fuel as can be "burned" without harming the atmosphere, and besides, the report maintains, the organization objects to development of the UK's Atlantic Frontier, because it’s pristine nature should be preserved for its own sake.

Chris Rose, deputy executive director of Greenpeace and author of the report, says, "There is no alternative to a phase out of fossil fuels if we are to prevent climate change. Since we cannot burn all that we already have, to explore for more oil is not only futile but extraordinarily irresponsible." He advocates investing in a solar industry (for England!) instead.

Armed with this attitude and with a trail of photographers in tow, Greenpeace commenced its anti-exploration campaign in London this summer by "invading" oil companies' headquarters, including those of BP and Conoco. This was followed by a 48-day occupation of the tiny rock outcropping of Rockall, which Greenpeace declared the independent "State of Waveland." This, to counter the UK's claim to the rock and those seas around it, according to the International Law of the Seas. Most significant of the activist group's summer Atlantic activities, however, and most dangerous to both crews and protestors, were Greenpeace's disruptions of several important seismic acquisitions being undertaken in the region for a number of major oil companies. During these disruptions, extensive 3D seismic shoots were being carried out by Horizon Exploration's vessel, Pacific Horizon, and by PGS's vessels, Atlantic Explorer, Geo Explorer, Malen Ostervold, and Walter Herwig. Greenpeace protestors used a variety of tactics to delay and disrupt these acquisitions, including boarding vessels and lashing themselves to onboard equipment, leaping into the frigid North Atlantic waters and swimming in front of vessels, making it necessary to veer away and invalidate the seismic lines being shot. They also climbed onto the airguns to prevent them from being triggered, used inflatables to traverse the streamer lines, and even stealing 10 of the tail buoy navigational systems (later returned via oil companies' offices in London). And, of course, MV Greenpeace itself was used frequently to block the path of the seismic vessels.
Vanaf medio 2004 zijn we volop bezig geweest om de werkportefeuille van Exploratie te verjongen. Dat gaat via biedingen op exploratielicenties, directe onderhandelingen met overheden, het verkopen van marginale velden en het vergroten van de belangen in gebieden waarin we al sterk aanwezig zijn.

Acreage staat aan het begin van de hele ‘voedselketen’ in reservevorming en bepaalt uiteindelijk voor een groot deel de toekomstige productie.


Hoge olieprijzen vormen een tweesnijdend zwaard”, zegt hij. “Je winst gaat omhoog, maar veel meer spelers zijn bereid topprijzen te betalen voor toegang tot acreage en om veel meer geologische en commerciële risico’s te lopen dan nog maar een jaar geleden het geval was. Bijna elke internationale, nationale en regionale oliemaatschappij kent nu een agressief programma om te groeien in elk bekken op de wereld.”

“Zo rond 2000 waren onze grote concurrenten in exploratie de andere particuliere oliemaatschappijen, de ‘super majors’ als ExxonMobil, BP en Total. Plus regionale oliemaatschappijen met een al wat langer bestaand relatief klein buitenlands programma, zoals bijvoorbeeld Statoil, Norsk Hydro en tal van Amerikaanse en Britse ‘independents’. Deze groep heeft inmiddels ook wereldwijde ambities, net als staatsoliemaatschappijen met een grote binnenlandse reservebasis en productie, zoals Petronas uit Maleisië en Petrobras uit Brazilië. De jongste ontwikkeling is de komst van staatsoliemaatschappijen die vanuit een relatief kleine thuisproductie

Is Bichsel verbaasd over de snelheid waarmee deze nieuwe spelers zich de technologie en ervaring eigen hebben gemaakt om deze wereldrol te kunnen spelen?

“Nee, het is een logisch gevolg van de globalisering van kennis en de razendsnelle verspreiding ervan door de moderne informatietechnologie. Bovendien hebben de grote oliemaatschappijen, zeker ook Shell, al lang joint ventures met deze nieuwe spelers, waarbij de overdracht van kennis en kunde uitdrukkelijk onderdeel was van het contract. Wat we nu zien is een logische uitkomst van iets wat we zelf in gang hebben gezet. Alleen is het tempo fors omhoog gegaan door de hoge energieprijzen.”

Gemeten in winstgroei zijn deze service providers dé grote winnaars van de nieuwe situatie. Het is te merken aan hun beurswaarde, die steeg in 2005 veel sterker dan die van oliemaatschappijen.

Matthias Bichsel
“Wat dat betekent voor de economie van nieuwe projecten?
Dat je als opdrachtgever in elk geval denkt dat de olieprijs zó hoog blijft dat de dure exploratie terugverdiend kan worden. Dan ga je er echter van uit dat de olieprijs niet meer - of althans niet lang - onder de $20-30 per barrel komt.”

Als je een beslissing moet nemen over een exploratieboring naar een klein veld, dicht bij bestaande producerende velden en infrastructuur, zodat je een vondst binnen een paar maanden tot productie kunt brengen, kan een referentieprijs van $40 zelfs nog conservatief zijn.

Maar als het gaat om een investeringsbeslissing in een potentiële megaproject, waarin het makkelijk vijf tot tien jaar duurt voor de eerste productie op gang komt, neem je waarschijnlijk een andere, of in feite een set aan referentieprijzen, om te bepalen of het rendement voldoende is.”

*Kan de wereld die groei leveren?*  
“De vraag kan worden uitgesplitst: Zijn die koolwaterstoffen er? En kan de productie ervan met de helft toenemen?”, analyseert Bichsel. “Aanhangers van de Peak Oil theorie zeggen dat we al bijna de top in productie hebben bereikt. Ik geloof daar niet in. Er is nog heel veel olie en gas te vinden in conventionele reservoirs en er is naar schatting nog iets van drie maal meer olie en gas te winnen uit onconventionele voorraden, zoals zware olie, oliezanden, schalie, verontreinigd gas en gas in moeilijk producerende reservoirgesteenten.”

Dé uitdaging wordt om op alle fronten in zowel exploratie als productie de technologie zoveel te verbeteren dat we tegen minder kosten meer olie- en gasvelden kunnen vinden en produceren”, legt hij uit. “En we moeten meer synergie tot stand brengen met de ontwikkelingen in de downstreamsector van ons bedrijf, om olieproducten te maken uit gas, steenkool en biomassa. Gelijktijdig moeten we oplossingen bedenken voor de CO2-problematiek.”

Eerste windmolen op zee


Met behulp van een kraanschip werd de 37,5 meter lange paal op zo'n 23 mijl uit de kust, ter hoogte van Zandvoort, in de Noordzee verankerd. "De Nederlandse overheid treuzelt al jaren met de uitvoering van plannen voor windenergie. De vergunningsprocedures voor nearshore en offshore windparken verlopen tergend langzaam", vindt Greenpeace.

In schril contrast daarmee krijgen olie- en gasbedrijven zonder problemen vergunningen om naar nieuwe voorraden fossiele brandstoffen te boren. Bovendien wordt gaswinning op de Noordzee door de overheid gestimuleerd met 100 miljoen gulden per jaar.

Om de regering te wijzen op de mogelijkheden van windenergie stuurt een computersysteem in de windmolen elke dag automatisch een e-mail naar kabinet, kamerleden en directies van energiebedrijven waarin de opbrengst van de dag wordt omgerekend in bespaarde CO2.

Een turbine van 3 Megawatt kan op zee genoeg elektriciteit produceren voor minimaal 3000 huishoudens per jaar. Greenpeace wil dat er over twintig jaar 10.000 MW vermogen aan windenergie neergezet is op het Nederlands Continentaal Plat. Hiermee kan in een derde van de Nederlandse behoefte aan elektriciteit worden voorzien.
