The introduction of LNG as marine fuel in the Dutch shipping industry

A strategic roadmap for Royal Haskoning

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Preface

This thesis is submitted in candidacy for the Master of Science in Systems Engineering, Policy Analysis and Management (SEPAM) at the TU Delft in Delft, Netherlands.

The announced new emission rules regarding sulphur and NOx by the EU made the shipping industry seek for new alternative marine fuel options. This report provides insights about the new developments regarding LNG as marine fuel in the Dutch shipping industry.

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Summary

In 2015 new emission restrictions regarding sulphur and nitrogen oxides (NO\textsubscript{x}) will be introduced for ships by the European Union (EU) in the North European Emission Control Area (ECA) region. The current used marine fuel oils (MFO) will not be able to fulfill the new requirements and therefore other marine fuel options, like Liquefied Natural Gas (LNG), Marine Gasoil (MDO/MGO) and Heavy Fuel Oil (HFO) with scrubbers could be solutions. In this research the current market situation of the shipping industry in the Netherlands is explored, related to the opportunities and risks regarding the use of LNG as marine fuel in the future. This report brings more insights on how actors could position themselves in this future, taking the uncertain developments into account.

Research approach

This research has mainly focused on the Dutch shipping market (chapter 1). The technical, institutional and process mechanisms of the system have been analyzed to get more insights into the developments of LNG as marine fuel (chapter 2 and 3). In previous researches mostly this subject is analyzed through economic methodologies to explore risks and opportunities in the market. However, within the context of these researches, this study provides a unique approach through applying the so-called TIP framework. This framework, next to the technological segments of this topic, analyzes the institutional and process aspects as well. A literature study has been conducted to gather information about the current developments in countries where LNG is used as marine fuel. To build upon the information from the literature and to map the developments in the Netherlands, experts of different market players are interviewed. Thereby possible strategies of market players are mapped (chapter 4). Furthermore, through developing socio-technical scenarios future uncertainties of the system were clarified (chapter 5). Finally the developed scenarios are used to test possible strategies of market players regarding the use of LNG as marine fuel in the near future, before 2030 (chapter 6). This study showed how several market players could deal with the introduction of innovative marine fuels towards a transition in the shipping market. Secondly this study presents what the added value could be of the use of socio-technical scenarios in exploring new system innovation in the Dutch shipping industry.

Barriers to LNG implementation as marine fuel

First barriers to implementation of LNG as marine fuel were determined based on literature and interviews with experts. Here, according to the TIP-approach, the technical, institutional and process barriers, which resulted from these methodologies, are presented.

The first and most important technical barrier is the lack of developed infrastructure: the missing bunkering infrastructure for LNG. At the moment there are no bunkering facilities in the Netherlands. LNG as marine fuel is used mainly in Norway nowadays where they have a solid LNG bunkering infrastructure for LNG vessels. Compared to other countries, like Denmark, Sweden, Netherlands and Germany they are far ahead in the use of LNG as marine fuel. This is because the Norwegian government has set up a NO\textsubscript{x} fund which finances market players developing clean technology, like the use of LNG as marine fuel.

From an economic perspective, the price of LNG in the near future is also a barrier. The price is highly uncertain, because it depends on many factors like logistic costs, international gas prices and total demand in the market. Because there are no reliable comparative economic studies between different marine fuel options due the uncertainties (LNG price, Oil price, development of scrubber technology etc. which resulted from literature studies and in-depth interviews) shipping companies are not able to make a choice between the different fuel options for their businesses.

Furthermore, the undeveloped standards for bunkering stations and the missing legislations to use LNG as marine fuel are institutional barriers in the market which also delay the introduction of LNG as marine fuel.
Also, the current uncertainty of the different stakeholders positions and roles within the LNG market in the Netherlands could be denoted as an institutional barrier. The current important market players are the shipping companies, the bunkering operators, ports and the Dutch government. The shipping companies will determine which alternative fuel they will use to fulfill the new emission requirements. They will start up the demand for LNG in the market. The other market players will provide the supply in the market, like LNG bunkering infrastructure, engines, legislation and standards. These market players all depend on the decision of shipping companies regarding which marine fuel they will use in the future, but their decision is not clear as yet. Linked to this, within the market the developments of legislation and standards are also in a slow process. The industry is open towards new innovative ideas, but market players willing to invest in LNG are searching for certainties and do not want to take high risks in this economic unstable time. This slows down the introduction of LNG as marine fuel in the shipping industry. What is wise for these parties to do in this complex, multi-actor environment, taking the uncertainties of the future into account?

From a process perspective, the lack of decision making has a consequence that other market players, like LNG bunkering operators and ports, are also in a wait and see position and postpone their business decisions. Therefore there is a mismatch within the market where no vessels are produced which could run on LNG and no infrastructure is available to bunker fuel for these vessels.

Hence, from these barriers it can be noticed that the technical barriers are not the critical problem. The biggest challenges to get market players prepared to invest in LNG relate to economic and institutional barriers. No market player has the power to overcome these barriers by itself. Therefore possible strategies for market players will be developed to support the decision making process.

Marine fuel scenarios
To help market players in developing strategies in the market for their businesses, scenarios are developed using technological transition or system innovation theories. The three different developed scenarios in this research indicate that in the short term, MGO will be the most attractive marine fuel for the shipping companies. In the middle long term, LNG will probably compete with scrubber technology in the shipping market. The socio-technical scenario analysis (chapter 5) resulted in the following mainstream possible future global scenarios:

- **Introduction of LNG (scenario 1):** One scenario that could occur is the slow introduction of LNG, but on the middle long term fast development of LNG as marine fuel in the shipping industry. After 2020, LNG could gain more market share when the LNG price stays attractive and the uncertainty regarding missing institutions and bunkering facilities is taking away.

- **Hybridization (scenario 2):** Another scenario which could occur is the hybridization in the market, which combines different marine fuel solutions within vessels. MGO will be in the short term the marine fuel which will provide the shipping companies the alternative fuel to meet the emission rules. After 2020, LNG can become also attractive when the uncertainties like standards and legislation and missing infrastructure are taken away.

- **Scrubber technology (scenario 3):** A scenario which also could occur is that scrubber technology will be more attractive than LNG after 2020, because of the low HFO prices and the secure current bunkering facilities. The missing standards, legislation and infrastructure for LNG will result in market players using scrubber technology to fulfill the emission rules.

Taking the current developments into account, it seems possible that the second scenario ‘hybridization’ will occur. However, it would not be wise for market players to only bet on one possible scenario. Therefore, robust market strategies are recommended in this study to market players by considering all three different scenarios. The following recommendations are given:
Recommendations for shipping companies

Taking the scenarios into account, it can be considered that MGO will be the next short term step for the shipping companies in the future. The uncertainties regarding the infrastructure and price of LNG, the untested HFO scrubber technology and waste handling make it risky for shipping companies to totally adjust their vessels to LNG in the short term. From 2020, shipping companies could follow different strategies. Scenarios 1 and 2 show that LNG could have a market share between 20% and 30% and will grow further after 2030. Scenario 1 shows a slow penetration of LNG in the shipping market. Scenario 3 shows a more successful penetration of scrubber technology and an ignorable presence of LNG as marine fuel. Regarding the future uncertainty, it is recommended for shipping companies to focus on a process approach of the system, in which openness is required towards the market and preparedness to cooperate with other market players. One example can be given: Reederei, Koedood and Wartsila are now cooperating to clarify what the cost will be of different alternative fuels, by setting up test cases. Similar projects can be set up by other shipping companies to get more trusted with technology. Also cooperation with bunkering operators and government could be set up to get more insights in the required standards for bunkering infrastructure and possibility of financial support from the government. Cooperations and alliances could be formed to test different options and to get more insights in required standards for safety and ship design.

Recommendations for Ports

They face risks concerning the investment which could be earned back from the LNG activities they will conduct in the future. It can be risky if LNG will not be used as marine fuel in the future. Looking at scenario 1 and 2, LNG will probably have a solid share in the shipping industry in the middle-long term. Also the developments in Western-Europe sketch that LNG will be attractive for inland and short sea shipping. Only if scenario 3 occurs the ports will not have positive results regarding their LNG investments. In this perspective it is recommended for the ports not to choose between LNG or HFO too early, but to provide the infrastructure (albeit on a small scale) for both of the marine fuels. The current standards and legislation for bunkering facilities are undeveloped. Therefore, the ports could start to cooperate with bunkering operators and shipping companies to accelerate these developments in the near future.

Recommendations for bunkering operators

In scenario 1 and 2 in inland shipping and short sea shipping there is a potential market to use LNG as marine fuel. In these two scenarios along the important inland waterways like the Rhine, new LNG bunkering facilities will have business potential in the future. However the operational profits will possibly only occur after 2020 in scenarios 1 and 2. It is expected that the demand for LNG before 2020 will be low, so in the short term a profitable business is not expected for the bunkering operators, because they heavily depend on the demand for LNG in the market. Based on scenario 3 LNG bunkering facilities will not be profitable at all because HFO will be the attractive fuel in the shipping industry.

A suggestion could be for the short term for the operators to work more closely with shipping companies in order to gain more confidence in LNG and get trusted with technology. Also, by doing so, the uncertainties like the unavailability of infrastructure and LNG demand in the market could slowly be taken away. Knowledge institutions and engineering companies could also get involved in order to develop new business opportunities. Parties like Deltalinqs, TNO and the TU Delft could act like a facilitator between private market players and bring experience and knowledge together. Currently, the uncertainties in the market make the actors too passive. They do not have the trust to invest in LNG businesses and do not want to take the risk by themselves. The added value of facilitator could be to trigger the market players to work together. By cooperation the developments of new standards and legislation could accelerate and the risks could be divided.
Recommendations for the Dutch government

One of the options for the Dutch government would be to invest in a stronger institutional framework (legislation and standards for LNG usage) for the shipping industry. Looking at scenario 1, it can be noticed that this will help the system to accelerate the introduction of LNG in the shipping industry. Besides this, market players will have certainties and could adapt their businesses to the rules in the market. If this is not done by the government, LNG as marine fuel will not play a significant role in the Dutch shipping industry. This can also be noticed in scenario 2: the market is accelerating the implementation of LNG when legislation starts being enforced. Also the same can be noticed in the last scenario: the shipping industry is not fully developed and prepared to use LNG, which makes the scrubber technology a more attractive alternative.

In all the scenarios it can be noticed that legislation and standards would help or accelerate the introduction of LNG as marine fuel in the industry. However, is this the aim of the government? Is it important that the share of LNG vessels increases in the Dutch waters? The main idea is to reduce the sulphur and NO\(_x\) emissions. When the government only focuses on LNG, will this not disturb the competitiveness in the market where market players also invest in other emission reducing technology? If the government could financially support all the technologies which will help to reduce the emission, a fair game will be introduced in the market. This is not an eye opener, because the same policy is carried out in Norway by the NO\(_x\) fund. A financial policy will probably cost the government more, but it will give more incentives for market players and will help to take the uncertainties of the future into account. Only focusing on LNG legislation and standards would not be the most robust alternative, because also for the Dutch government it is important that the emission reduction goals will be feasible in 2015. There remains the risk that LNG will not be successful at all and focusing on one marine fuel will not be a solid policy for the future.
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### Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>LNG</td>
<td>Liquefied Natural Gas</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>ECA</td>
<td>Emission Control Area</td>
</tr>
<tr>
<td>bcm</td>
<td>Billion cubic metres</td>
</tr>
<tr>
<td>SOx</td>
<td>Sulfur Oxide</td>
</tr>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>Nitrogen Oxide</td>
</tr>
<tr>
<td>RoRo</td>
<td>Roll on/Roll off</td>
</tr>
<tr>
<td>RoPax</td>
<td>Roll on/Roll off and Passenger</td>
</tr>
<tr>
<td>SECA</td>
<td>Sulfur Emission Control Area</td>
</tr>
<tr>
<td>SIGTTO</td>
<td>Society of International Gas Tanker and Terminal Operators Ltd</td>
</tr>
<tr>
<td>DNV</td>
<td>Det Norske Veritas</td>
</tr>
<tr>
<td>DF</td>
<td>Dual-Fuel</td>
</tr>
<tr>
<td>NPV</td>
<td>Net present Value</td>
</tr>
<tr>
<td>SECA</td>
<td>Sulfur Emission Control Area</td>
</tr>
<tr>
<td>SCR</td>
<td>Selective Catalytic Reduction</td>
</tr>
<tr>
<td>MN</td>
<td>Methane number</td>
</tr>
<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
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<tr>
<td>HFO</td>
<td>Heavy Fuel Oil</td>
</tr>
<tr>
<td>RH</td>
<td>Royal Haskoning</td>
</tr>
<tr>
<td>TIP</td>
<td>Technical, Institutions, Process</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>STSC</td>
<td>Socio Technical Scenario</td>
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<tr>
<td>MLP</td>
<td>Multi-Level Perspective</td>
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<tr>
<td>MGO</td>
<td>Marine Gas Oil</td>
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<tr>
<td>MDO</td>
<td>Marine Diesel Oil</td>
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1 INTRODUCTION

Developments in the shipment industry show that there is a possibility in which the industry will embrace LNG vessels in the future. The EU has announced to adapt the emissions allowed on the ECA (Emission Control Areas) by 2015, presented in Figure 1. New legislations allow only less than 0.1 % sulphur in fuel oil used by vessels (TEN-T, 2011) as presented in Figure 2. One year later, in 2016, IMO member states have already proposed for a Nitrogen Emission Control Areas (NECA) in which new ships must fulfill to the new required nitrogen oxides reductions. The NOx emission standards are referred to TIER standards. The TIER 3 will be introduced as mentioned in 2016, which will require a NOx reduction of more than 75 % of the current emissions of the vessels (Magalog Project, 2008)(Figure 4). The current shipping vessels will not fulfill the SO2 and NOx emission restrictions, which will lead to an adaptation of the vessels by the shipping companies (Bengtsson, Andersson, & Fridell, 2011). Involved actors, like shipping companies, gas companies, ports and engine companies see opportunities to invest in LNG.

LNG is a liquid which needs 1/600\textsuperscript{th} of the volume for the same amount of natural gas energy. It’s cooled to about -162 degrees and can thereby be transported long distances. Because the transportation and storage cost of LNG dropped in the last decade, many LNG projects rise in Europe and the Middle East. Another factor which triggered the interest in LNG is the fact that countries are seeking ways to become more independent from one natural gas supplier (Hansson, 2008). The recent problems between Russia and Ukraine made the gas prices increase in Europe. LNG provides a new supply of gas into the energy grid of a nation by an alternative way, which is less expensive than gas pipelines. This LNG is produced mainly in the Middle East region and Africa by countries like Algeria, Nigeria, Qatar, Oman and United Arab Emiratis. Figure 3 presents the global gas routes in the world. Here it could be noticed that Europe mainly depends on pipeline gas and that East Asia already uses LNG from the Middle East.
LNG is the cleanest fuel between the current valid fuels for vessels. When ships use LNG as fuel, no sulphur will be exposed to the environment and the reduction of NO\textsubscript{x} will be more than 80-90% than conventional fuel (Hansson, 2008). Converting ships on fuel or building new ships on LNG will allow shippers to fulfill the announced new emission standards in the ECA regions, but LNG is not the only alternative option for shippers and the marine industry.

Other alternatives to meet the emission standards can be achieved by using low-sulphur Marine Gasoil (MGO) or installing exhaust scrubbers on Heavy Fuel Oil (HFO) (Alvestad, 2011). MGO doesn’t require extra volume for storage as for LNG and retrofitting of the engine is not required. The investment costs will therefore be minimal (Levander, 2011). HFO will also fulfill the requirements in SECA 2015 and the TIER 3 standards. Further stricter emission standards will require scrubbers for SO\textsubscript{2} and Pm removal. This will lead to more capital investments as to more produced wastes by the scrubbers (TEN-T, 2011). The ports are not pro HFO bunkering because of the environmental risk regarding the handling. Currently there are no guidelines for Ports to handle the waste. Here it can be mentioned that the conventional fuels require less adaptation of the fuel and engines, but require additional services and places where reduction in sulphur and NO\textsubscript{x} can be realized. On the other hand, LNG requires new engines and more storage place in the vessels for fuels and new infrastructure for the accessibility of vessels.
Nowadays, new projects rise to build LNG import terminals in Europe to secure the energy supply. Belgium, France, the Netherlands, Denmark, Sweden and Mediterranean countries are planning to build these new LNG terminals in the near future (Bagniewski, 2010) (Dahlstrom & Lundh, 2011). Some of these countries have already these import terminals and looking for opportunities to use LNG in their energy supply and other industries. This also provides alternative application of LNG, such as LNG as fuel for the shipping industry as mentioned above. The regulation which will be valid after 2015, the possible cost reductions in the use of LNG by its growing implementation in Europe, and the environmental benefits are developments which makes it interesting to analyze LNG as fuel in more detail. The EU announced the new emission regulation to the restricted ECA region, namely the North and Baltic Sea. Norway is one of the first countries where vessels already use LNG as marine fuel. They form an example for other countries in the region and the local firms and industries are now active in other countries to promote LNG as marine fuel. The expectations of the IMO are that the new emission restrictions will be internationally valid before 2020, but for this is uncertain.

Currently, the technology for LNG is mature enough to explore the possibilities in this industry, but at the moment there is no infrastructure in the Netherlands to refuel LNG ships. There are firms that are converting their vessels to use LNG instead on oil. Involved actors are cautious to invest and bear the risks that come with this new and innovative system. The problem is that if there is no infrastructure for LNG vessels so no investments will be conducted to build LNG vessels by shipping companies. On the other hand: if there are no ships which will demand LNG as fuel, there will not be an infrastructure needed in the Netherlands. Another important aspect is that the safety regulations regarding LNG are not available. For now, actors don’t have the knowledge or information which probably will constrain their investments in this market. This institutional aspect is an important uncertain factor which will influence the technical part of the future LNG system.

![Figure 4 - NOx limits](Pederson, 2008)

Despite the risks and uncertainties, different market players in the Netherlands are nowadays looking for business opportunities in the new developing LNG market in Europe. The Ports are researching the opportunity to provide LNG as bunkering fuel. Shipping companies are important players who must be the one to fulfill the new emission regulation. Bunkering fuel operators are researching new ways to facilitate LNG infrastructure in the future. The engine producers are promoting their new gas engines in the market so they can win a great market share. As mentioned earlier, there are uncertainties in using LNG which will make the market players think about their strategies in the future.

In the following section 1.1 and 1.2 the goal of this research and the knowledge gaps in the literature will be given. Section 1.3 will present the research questions. Section 1.4 will describe why this report will have scientific and social relevance and added value in the literature. Next in section 1.5, the methodologies used for conducting this research will be explained. Finally indication of deliverables of this research will be presented.
1.1 RESEARCH GOAL

In the current transport system in the shipping industry, the new regulations will bring changes in time. This can cause an innovate adaptation or technological transition to LNG as a new fuel for vessels in the Netherlands and Western Europe, but the industry can also adapt incremental improvements of the current fuel engines. Therefore, the stakeholders in the market and their behavior will be important for the success of LNG in the Netherlands. Each actor in the market will follow a strategy and this will lead to possible different future scenarios for Western Europe. Also other factors (technical, institutional, process related) like LNG price, demand of LNG, investments in LNG ships will influence the success of LNG in the further. Therefore the problem statement and goal of the research can be formulated as follow:

There is uncertainty in the shipping industry regarding the future fuel for vessels, because of economic implications (costs and effects of to be adapted fuel alternatives like LNG, MGO, HFO), safety regulations, position of involved stakeholder, infrastructure implications (bunkering, storage and location constraints) and many other factors.

In this research the current market situation of the shipping industry in the Netherlands will be explored, related to the opportunities and risks regarding the use of LNG as marine fuel in the future.

In this research the behavior of important stakeholders in the shipping market, where LNG as marine fuel will compete with other fuels, will be analyzed. Also possible scenarios which can occur in a complex environment and multi-actor setting in the shipping market will be developed to test the robustness of the actors strategies. From this point, a stakeholder analysis will be given to particularly Royal Haskoning (RH). RH is an independent international consultancy with a technical background. Developing innovative and sustainable solutions for issues related to interactions between people and environment are their core business. RH provides multi-disciplinary services that relate to infrastructure, ports and industry. RH wants to know which opportunities there are and how they can respond to the demand of new and raising LNG markets. This because many of their clients are mainly the Ports and firms which are active in the Ports, like: VOPAK, Argos and others. These companies are related to bunkering activities and storage of oil and gas. As LNG is a ‘hot issue’ in the Ports and firms in the shipping industry, this topic becomes also interesting for RH, since they provide services for many of these companies. These services include for example the design of terminals, storage tanks for oil and gas, port infrastructure and logistics. Therefore, it’s important that RH gains more insights about the developments of the market and how they can serve their clients in the future regarding LNG.

For now, RH is interested in how the market of LNG will evolve and how the actors will possibly behave in the future. For example: will it be interesting for RH to specialize in the development of a design for a LNG terminal in the Ports, or will it be more interesting to specialize in developing the design of an offshore floating bunkering facility for LNG? This question can only be answered if the strategies of involved actors will be analyzed and the future developments and the demand in the shipping industry will be explored. These analyses will help RH to take a position in the LNG market so they can expand their services regarding LNG for their current and possible new clients.

1.2 KNOWLEDGE GAPS

A technical knowledge gap can be seen in the uncertainty of harbor design (dealing with the new LNG supply and demand, positioning, and capacity). All these aspects have an influence that are to be researched to gain knowledge and insights that can be helpful for RH in future contracts. Some analyses have already been made (Dahlstrom & Lundh, 2011)(TEN-T, 2011).

Current studies focus on the environmental effects of LNG in shipping industry (Verbeek, Kadijk, & Wulffers, 2011)(de Ruiter, 2010) (Baumgart & Olsen, 2010). Also economic feasibility analyses are conducted with the

It remains unclear how the market will evolve in the LNG market, especially in the Netherlands and Western Europe. Hence, in Northern Europe some LNG ships already exist and also infrastructure has been build. For now, it is unclear how this system innovation will evolve in the future and how stakeholders will influence the developments or will be influenced by these developments. As can be said, namely the institutional part of the system is underexposed in this case. For now, the focus mainly goes to economic feasibility of the LNG in relation to conventional fuel and the feasibility of emission reduction in the shipping industry. This research therefore will approach from an actor perspective, which will broaden the available current literature regarding LNG as fuel for vessels in the shipping industry.

1.3 RESEARCH QUESTIONS
In this research answers will be given to the following main question and sub questions:

What perspective does LNG as fuel offers to the shipping industry in the Netherlands within a multi-actor setting, where developments in this market are uncertain and complex?

- Q1. What are the technical, institutional and process mechanism in the shipping industry regarding LNG as fuel for vessels (in comparison to other fuel options: MGO and HFO)?
    ▪ Objective RH. Structuring within causal diagram for understanding the mechanics of the system.
  o Method: literature study (system innovation), structuring within a TIP (Technology, Institutions, Process) approach. Integration between the three levels. Four Layer model to analyze the institutions more in depth.
  o Output: Input for Q2> clear system exploration and expose important Institutional aspects which will be used to explore the actors/regulations in the market.

- Q2. Which actors will be critical in this multi actor setting and what strategies will they follow?
  o Identifying actors: Desk research>> internal as external stakeholders will be explored
  o Network diagram: Structuring the actors in the market. Focusing on activities the activities in the chain of the system and the position of the actors in this chain.
  o Method: semi structured interviews, to gather recent data.
  o Output: Clear structuring and understanding of behavior of actors in market.

- Q3. Regarding the strategies of actors and the developments in the market, which different scenarios can occur during the introduction of LNG in the shipping industry?
  o Combining the output of Q1 and Q2 to identify potential strategies which can be followed by RH. Internal stakeholder interviews
  o Socio-technical scenarios with using data from interviews and literature.
  o Output: reduced future uncertainty in market.

- Q4. What are the opportunities and risks for market players in this case and how can they position themselves in the new rising market?
  o Identifying possible roadmap for actors, short term and middle- long term strategies.
  o Output: Recommendations.
1.4 SOCIAL AND SCIENTIFIC RELEVANCE

Currently the Dutch government is focusing on policies to reduce the emissions in different areas like, traffic and industries. For example: the Dutch government is subsidizing firms to make the introduction of electric vehicles in the society a success. There are incentives for consumers to purchase an electric vehicle. There are firms, like Essent, that are investing heavily in the charging infrastructure for these electric cars. If these policies prove to be a success, the CO2, Pm10 and NOx reduction goals will be achieved. Like the electric car industry, the shipping industry finds itself in a familiar situation. The possible transition to LNG as fuel will lead to reduction of greenhouse gasses within the Netherlands. This study will provide more insights regarding the future of LNG in the Netherlands. The knowledge gained by this research about the behavior of stakeholders and the future scenarios can be used by the Dutch policy makers. This can finally lead to measurements by the government which can have positive effects on the environment. Therefore it can be noticed that this research will contribute to the society.

The introduction of an innovative system in a complex and multi actor environment is a difficult project. Studies are made about the economic and environmental effects of LNG as fuel in the shipping industry. Most studies just look to one aspect of the system. It can be noticed that the focus mainly lies on the feasibility of the innovative LNG system from an economic point of view. This research will embrace an integrated and holistic approach in which technical, institutional and process levels will be handled to explain the dynamics of the system innovation. This will help to get more insight in how this innovative transition of LNG as fuel in a complex situation can evolve and how actors in this market will behave. The uncertainty about the future will be reduced by building scenarios and exposing the strategies of stakeholders. This research will contribute to the current literature which is available about LNG and will add knowledge gained from an actor perspective.

Additionally decision makers in the shipping industry can make use of the knowledge gained from this research. The future scenarios will give for example RH insight in how they can determine their strategies in the market.

1.5 RESEARCH METHODS

To analyze and answer the questions, methods will be used to gain the required knowledge (Figure 5). First a literature study will be conducted to get insight about the developments in the current LNG market in the shipping industry. The situation in Norway will be compared, because they have a more mature market in this field. This will help to answer question 1, and will set the basis to tackle the following questions. Secondly interviews will be held to gain information from the real world. These gathered knowledge from interviews and literature will be used to conduct the analyses in this research. Interviews will be taken from experts because LNG in the shipping industry is an ongoing development at the current time and the interviews with experts in the industry will provide real and valid information about how actors can behave for now and the future and how the developments will occur in the future.
The current developments in the market will be analyzed within a TIP (Technical, Institutional and Process) framework (Koppenjan & Groenewegen, 2005). The system will be approached from a broad perspective, where the integration within the three levels will be presented. Here opportunities and threats in the new possible LNG market in the shipping industry will be derived. Hereby, the situation of Norway will also be used. The focus will mainly be on the actors in the system and how they will behave in the future. Also other institutional aspects regarding safety and regulation will be analyzed. During the literature study, theories and framework about system innovation and technological transitions will also be used to analyze LNG as fuel option in the shipping industry. This desk research will be conducted to present the current state of the industry and to gain knowledge about the developments in the market. The TIP framework will help to structure the challenges in the market and will help to get a clear picture in where the interactions between the different levels (technical-institutional-process) will be interesting and important for actors.

Interviews
Interviews will be conducted to collect information/knowledge from experts. This will support the literature study which simultaneously will be conducted. The information collected from the interviews, will be used as input for the stakeholder analysis and the socio technical scenarios. This will lead to actual information from the practical real world. This method has been chosen, because interviews can help to gain more tacit knowledge from experts who are not captured in the current analyses. Thereby, the gained information from the literature can be compared with the information from interviews and vice versa. This finally will result in a robust way in validating the information which will be used for the analyses. Experts from the TU Delft, the government and private companies will be interviewed to get information from different perspectives. The experts who will be interviewed:
Table 1- List of experts interviewed for this research

<table>
<thead>
<tr>
<th>Company/institution</th>
<th>Interviewee: Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research institute</td>
<td>Business Developer in the oil and gas market</td>
</tr>
<tr>
<td>Engine producers</td>
<td>Business Developer Gas and Power</td>
</tr>
<tr>
<td>Ship-owner Association</td>
<td>Technical and Environmental Consultant</td>
</tr>
<tr>
<td>Bunkering Operator A</td>
<td>Business Development Manager</td>
</tr>
<tr>
<td>Knowledge Institute</td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td>Royal Haskoning</td>
<td>Consultant Oil and Gas</td>
</tr>
<tr>
<td>Royal Haskoning</td>
<td>Business Developer</td>
</tr>
<tr>
<td>Umbrella organization Ports</td>
<td>Consultant Innovation &amp; Environmental Affairs</td>
</tr>
<tr>
<td>Shipbuilder</td>
<td>Project Engineer R&amp;D</td>
</tr>
<tr>
<td>Bunkering operator B</td>
<td>Director</td>
</tr>
<tr>
<td>Gas Transporter</td>
<td>Business Developer</td>
</tr>
</tbody>
</table>

This broad set of interviewees will provide information/knowledge from different perspectives. The selection method of these actors has primarily been done by looking which actors are currently active regarding LNG. As mentioned in section 2.2, many actors active in the Ports have their own ideas about the developments within the shipping industry. Besides the industry itself, it will be important to interview other experts, which have a different perspective on this topic. Therefore, experts from research institutes will be approached to give their insights about the developments of LNG in the Netherlands. It can be noticed that the list provides experts from research institutions, ship builders, engine producers and bunkering firms. This will help to analyze information from different perspectives and to validate the gained information. It is expected that experts will have different options about LNG and the developments, which will help to provide a different sets of scenarios for this research (research question 3).

**TIP approach**

As mentioned in the research goal, this research will be conducted from an actor perspective. To understand the institutional level of the LNG market and the interrelations between the other levels of technology and process, the TIP (Technology, Institutions, and Process) approach will be used (Koppenjan & Groenewegen, 2005). The TIP approach will help to structure the challenges and mechanism of the system from different perspectives in the market and to expose the interrelations between the three levels. It will give a clear picture of the complex system of the possible LNG market and will help to scope the focus of this research (research question 1). This approach has been chosen because the system of LNG as fuel in the shipping industry which will be researched has specific characteristics (Koppenjan & Groenewegen, 2005):

- “The system has a technological component. But this is not the only determining factor of the system. The technological part of the system is important, but also the decisions of the actors in the system will have important influence.”
• “Multiple parties are involved: these can be private and/ or public. The functioning of the system will have influence on both of these parties.”

• “The functioning of the system can be influenced by market forces and regulation.” In the case of LNG in the Netherlands, the IMO has announced new regulation in 2015 for sulphur and NOx.

This approach will force to not only focus on the technical part of the system, but also to focus on the actors and their behavior during the transition to a new fuel system for vessels in the industry. As it is important to analyze the future development in the shipping industry and strategies of actors, it will be important to take different developments of technology, institutions and process into account. Therefore, the TIP framework will provide the base to bring different levels (T, I, P) in one framework and help to explore the interactions between the levels. This methodology is used to design a system, like infrastructures, city planning, services and other complex systems. In this research no designing will be conducted, but the methodology will be used to explore the market mechanism in the LNG system. In the literature many methodologies and techniques exist to analyze the market potential and risks (Aaker & McLoughlin, 2010). The following dimensions are generally used:

- Market size (current and future)
- Market growth rate
- Market profitability
- Industry cost structure
- Distribution channels
- Market trends
- Key succes factors

Another important and well know framework which mainly is used to explore markets is developed by Michael Porter. In his five forces analysis he identifies 5 factors that influence the market profitability (Porter, 2008). These frameworks and approaches are generally from an economic perspective. This research will use a non-common approach to explore the opportunities and risks of a new innovative solution in a market (LNG as marine fuel in the shipping industry), called the TIP approach. Thereby insights will be gained whether the TIP approach will have an added value in exploring new innovative solution towards transition in markets (Discussion chapter 8).

**Stakeholder Analysis**

This method will be used to make a clear picture of the involved actors within the future LNG market. The relations between the actors will be analyzed and their possible role in the future. Knowledge will be gained about how they will act in the market and which possible decision different actors will take in the future. Therefore, several stakeholder analysis theories and frameworks will be applied. Formal diagrams, the four layer model and the concepts of Dynamic Actor Network Analysis (Bots, 2008) will be used to apply the actor perspective approach in this research. This will help to answer research question 2 of the research and the outcome of the analyses will be used as input for the socio technical scenarios which will be developed in this market.

**Socio Technical Scenarios (STSc)**

The aim of this method is to design possible future scenarios which can occur in a technological transition or system innovation (Elzen & Geels, 2002). This method includes a systematic approach to build scenarios with a time span between 30-50 years. The current LNG as a fuel for the shipping industry shows that also in this case a possible transition may occur in the coming decades. Therefore, in this research this methodology will be used to make the scenarios within a sociotechnical environment, but the time span will be reduced. These scenarios will show the possible future developments of the shipping industry and the influence of LNG as fuel for vessels. As input, the behavior of the different actors which earlier will be conducted be included to support
this method. By this method, the possible future transitions in the LNG market can be explored (research question 3). This will give insight for different stakeholders, namely Royal Haskoning, to take the uncertainties into account when they will develop their strategies in this market.

**Strategy development**

For now, it’s difficult to sum up which possible strategies RH can follow, because the new possible LNG market is also new for RH, but to give an indication, possible strategies are presented below:

- Specialize in designing terminals and storage tanks for LNG in Ports
- Specialize in floating bunkering vessels for LNG bunkering
- Specialize in ship-to-ship transfer of LNG
- Specialize in the logistic chain of LNG transport from Port to client of LNG (Ballast Nedam, Rolande)
- Developing LNG supply chain to support bio LNG stations
- Focus not on the Ports, but on customers which are not related to port activities (like specializing in developing filling stations for trucks)

This short list gives just an indication of possible strategies. From this point RH has to decide which strategies they will follow.

1.6 **FINAL PRODUCTS**

It is mentioned this research will conduct new insight for the literature from an actor perspective. This research will produce an overview of possible strategies of the actors in the market and their influence on the market itself and vice versa. This will provide knowledge how this market can evolve in the future. Based on the developed scenarios, actors like the government for example, can use this knowledge in their policies to reduce emission in the shipping industry. Hence mentioned in 1.4, this research has a social relevance and will therefore make recommendations for policymakers regarding LNG as fuel for vessels in the Netherlands. A clear picture of developments will be given, so policymakers can use this in their future plans to reduce the emission pollution in the Netherlands.

Primarily this research will also deliver strategies to help RH to position in the new LNG market in the shipping industry. Future strategies will be explored and tested within the developed scenarios to make solid recommendations on how RH can invest their knowledge and resources in this new market. This theoretical framework and used methodologies will help RH to tackle new system innovations in other future markets. As this company has innovation as a core value in their business, this research will give them an alternative approach to deal with the complexity of a new innovative system in the future.
2 THE CURRENT MARKET SITUATION

As a starting point in this research the North European countries will be analyzed to see how LNG as marine fuel has developed in the past years. This because Norway firstly has used LNG as marine fuel and they have a certain developed market regarding the use of LNG in the shipping industry. First the developments in Norway will be analyzed. The current literature shows that all cases regarding the use of LNG as marine fuel refer to Norway. Next to Norway, the neighbor countries like Sweden and Denmark will be analyzed. After making the global developments in the North European countries clear, the market situation in the Netherlands will be described. This Dutch market regarding the use of LNG as marine fuel will be the scope of this research. This chapter will globally present the important developments in other countries and will serve as a starting point in this research.

2.1 NORWAY

Norway is a step ahead compared to other countries in using LNG as fuel for the vessels. The main driving forces are the large natural gas reserves and the absence of a national pipeline grid for gas (TEN-T, 2011). Therefore an alternative was needed to exploit the gas reserves in Norway. The transportation of gas as liquid has become an alternative solution to transport gas from the production plants to their customers in Norway and Europe. From 4 different production plants, LNG is transported to over 40 receiving terminals in Norway. The capacity and location of these productions plants are presented in the figure below (Marintek, 2012).

![Source of LNG](image)

<table>
<thead>
<tr>
<th>Local production (marked P)</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karmøy</td>
<td>20000 ton/year</td>
</tr>
<tr>
<td>Kollsnes1</td>
<td>40000 ton/year</td>
</tr>
<tr>
<td>Kollsnes2</td>
<td>80000 ton/year</td>
</tr>
<tr>
<td>Tjelbergodden</td>
<td>10000 ton/year</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150000 ton/year</strong></td>
</tr>
</tbody>
</table>

Figure 6- Production plants Norway

A new plant will be constructed with a capacity of 300.000 ton/year. These plants are called small scale LNG, because international production plants have an annual production capacity over three million ton/year (MAGALOG, 2008). From the production plants, LNG is transported to LNG receiving terminals with storage capacities, which are presented in Figure 6 with the blue circles. This is conducted by trucks or by LNG carrier vessels. After the storage at these receiving plants, bunkering of LNG to ship or onshore facilities can be conducted. Currently, four terminals in Norway are capable to bunker LNG to ships, namely: Kollsnes production plants, CCB Agotns Offshore base, Halhjem ferry quay and Ora. There are also bunkering facilities at Risavika production plant (TEN-T, 2011). Further logistical/technical analyses of the whole LNG chain will be presented in more detail in section 2.3.

These figures show that Norway has already a developed infrastructure for bunkering of LNG to ships. However, is there enough demand from the end consumer to use LNG as fuel? In the figure below, the current ships operating on LNG and the ordered ships which will use LNG as fuel are presented (DNV, 2011).
As can be noticed, currently vessels using LNG as a fuel are mainly used on car/passenger ferries. The ordered vessels show that LNG becomes also attractive in other shipping sectors, like: RORO (Roll on Roll off ships), PSV (Platform Supply Vessel), High speed RoPax (Roll on Roll off passenger) and general cargo transportation. The shipping industry in Norway expects a further growth in the amount of vessels on LNG in the coming years. Marintek and DNV expect at least 1/3 of maritime fuel in Norway to be LNG in 2020 (NHO, 2011).

The driving forces which have resulted in companies acquiring vessels on LNG in Norway are not only the international regulations (Tier 3) or the availability of bunkering infrastructure, but also institutional agreements developed by the Ministry of Environment. In 2007 a NO\(_x\) tax was established, which contained a 2 euro payment per kilo emitted NO\(_x\). This tax initiative was in the beginning not a success and therefore expanded with new complementary regulation. A NO\(_x\) fund was set up between 14 business organizations and the Ministry of environment (TEN-T, 2011). The main contents of this agreement which will be valid till 2017 (NHO, 2011):

- “Affiliated enterprises are entitled to exemption from fiscal NO\(_x\) tax”
- “All enterprises subject to NO\(_x\) tax may be affiliated (528 affiliated enterprises so far in 2011 )”
- “The NO\(_x\) Fund has to fulfill the obligations in the Agreement, sanctions if yearly targets is missed by more than 10 %”
- “Support to cover additional costs of investing in gas/LNG propulsion in shipping (up to 80 % of investment cost and up to € 44 per kilo NO\(_x\) reduced) in 2011 – 2015”
- “Other measures could receive up to 80 % of investment cost and up to 28 € per kilo NO\(_x\) reduced”

This fund made it very attractive for shipping companies in Norway to buy new LNG vessels. The government in the country helps to stimulate the industry and supports them in fulfilling the requirements needed in 2015 and 2020.
2.2 Denmark and Sweden

A short overview of the current situation in Norway has been given. Now it would be interesting to analyze how the situation is in the neighboring countries of Norway regarding the developments of LNG as fuel for shipping industry. A first literature study shows that these countries are in the beginning phase, and are way back in the developments compared to Norway. As an example: Denmark doesn’t have any LNG import terminal at all. Also not many studies can be found about the opportunities of LNG as fuel for the shipping industry in Denmark. One extensive study is done by the Danish Ministry of Environment (Danish EPA, 2010). This study shows the opportunities of the use of LNG and CNG for ships in Denmark, namely on ferry and cargo routes.

The table below shows the total amount of ships calling in Danish ports. It can be noticed that major shipping activities are conducted by ferries.

Table 2 - Ship calls in Danish ports (Danmarks Statistik 2010)

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>% 2007</th>
<th>2008</th>
<th>%2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship calls total</td>
<td>545249</td>
<td>552217</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cargo ship calls</td>
<td>28423</td>
<td>5.2</td>
<td>26120</td>
<td>4.7</td>
</tr>
<tr>
<td>Ferry calls</td>
<td>56826</td>
<td>94.8</td>
<td>526097</td>
<td>95.3</td>
</tr>
</tbody>
</table>

This study has defined four scenarios in which different assumption has been made regarding the percentages of the ferries and cargo transportation will use LNG as propulsion in the future. As a result of this research, the following graph has been presented:

Figure 8 - Results of comprehensive scenario (blue) and the dramatic scenario (red) for ports, vessels and LNG fuel consumption

Figure 8 shows even in the worst scenario (red) a conversion of 33% of the currents vessels in Denmark and the availability of 24 % ports (for LNG bunkering and storage) can lead to a total LNG consumption of 83 %. This is a very interesting and ambitious conclusion made by the Danish EPA, but it will be hard to understand the causes at this moment of this research.

In April 2011 the first LNG filling station has been realized in Sweden by AGA. This terminal has a capacity of 20,000 m³ per year. This terminal was mainly built to provide the gas grid in Stockholm and the industries with gas. Since the regulations in the SECA area become harder, this terminal became interesting to use it for bunkering facilities. Because of harder regulation, Gothenborgs Energi plans to build a terminal in Gothenborg that will be finished in 2013 (Dahlstrom & Lundh, 2011). Other ports will become also interesting in the future.
SWECO analyzed the potential of several other ports in Sweden for LNG bunkering activities (SWECO, 2008). The potential ports which can provide LNG bunkering services are shown in Figure 9.

![Figure 9 - Potential LNG ports in Sweden for RoRo and RoPax (Dahlstrom & Lundh, 2011)](image)

2.3 SITUATION NETHERLANDS AND OTHER COUNTRIES

The introduction of the emission regulation in 2015 will also affect the Dutch shipping companies. In the past two years many conferences are organized. The market players who can add businesses to provide LNG as fuel in the market are now looking for new opportunities. Because this research will be conducted to analyze the market situation in the Netherlands regarding LNG and to present the involved actors and their behavior, the detailed analysis will follow during the next chapters. In the end of this research the situation in Netherland will be clear.

Also countries in the Baltic Sea area like Estonia, Latvia, Lithuania and Poland are keeping track of the developments regarding LNG. Mainly feasibility analyses of LNG import terminals are conducted. The developments in that region are far behind compared to Norway. The first steps must be taken to realize LNG as marine fuel, like the realization of a LNG import terminal. Also East European countries seem to have a positive attitude towards the applications of LNG in their national industries. However it’s too early to make assumptions on how the developments in those countries will evolve in the future and if these countries will make serious business of LNG. These countries will fall out of the scope, because the focus will be on the market developments and future of the shipping industry in the Netherlands.
3 THE TECHNICAL MECHANISM IN THE LNG SYSTEM

A description of the technical level has already shortly been shown in the presentation of the situation in Norway. In this chapter, a further description of the technology in the system will be given. This will be part of the technical analysis of the TIP framework. The TIP method will be used as a framework to structure the literature and to give insight about the system from three different perspectives. By approaching the system from different perspectives the mechanisms, the opportunities and risks of the system can be analyzed better than only looking at one part of the system (in this research, the introduction of LNG as fuel in the shipping industry will be mentioned as 'system'). These analyses will form the base for the developing the scenarios in chapter 5 which will be used to test the strategies for the stakeholders in the market. The TIP framework will thus not be used to develop a new technical, institutional and process design.

The institutional analysis of the system will be analyzed more in depth compared to the technical part. This constraint has been chosen mainly because the literature concerning the technology regarding LNG as marine fuel is extensive. Also the scope of this research has been reduced to a more in depth analysis of the institutional part of the system, because as mentioned in 1.3: this part is underexposed in the literature. The institutional part of the TIP framework will follow in chapter 4.

The scope of the technical part will be the focus on the logistical chain of the LNG system. Different reports, articles and presentations of involved firms will be used to analyze the LNG chain and to present the challenges in the system. This chapter will provide a start up with the basic technical sub components of the system. The technical components will described incrementally more in detail during this research. The aim of this analysis is not to give a detailed description of the different technical developments, but to understand the basics of the technical mechanism in the system. This is going to be used in chapter 4 where the relations between the technical mechanism and the institutions will be given. For this analysis mainly literature has been used. Besides literature also interviews have been used as input.

3.1 LNG INFRASTRUCTURE

According to interviewees of the bunkering operator A, the bunkering operator B, the research institute and most of the literature an efficient logistical chain is required to realize LNG bunkering. The first step will be the import of LNG to a receiving LNG terminal. In Norway there are more than 40 LNG receiving terminals and 1/3 of these terminals are able to bunker LNG to ships. Norway is one of the few countries in Europe which has LNG productions plants, which allows them to produce in their own country. For example: Sweden has a LNG filling station built by AGA in Nynashamn that imports LNG from Norway, Rotterdam and Central Europe. After LNG is imported in the terminals, LNG has to be delivered to the customers. Several options are possible: by truck or by LNG carriers. This will depend on the demand of the customers: the more capacity that is required, the more LNG carriers will be used. The logistical chain has been presented in an IDEF (Integration Definition for Function) scheme, making the logistical chain more clear.
The activities on a receiving terminal have been presented in more detail: this is important, because this will provide the link between the supply chain of LNG to the end consumer (vessels or the national grid of the country). Figure 10 presents the receiving of LNG on an import terminal by ship. This activity is also conducted by truck, but only small amounts can then be transported.

As mentioned in the first chapter, the current infrastructure is not fully developed in the Netherlands, which makes LNG bunkering to vessels a challenge for the future. The literature shows that the missing infrastructure causes a chicken-egg problem. When there is no infrastructure available, it will be hard for the end-user to demand LNG. The process A3 ‘receiving terminal’ will important in the logistical chain. When looking to the other parts of the logistical chain, it can be noticed that transportation and storage capacities are the other parts of the chain. These activities will not provide technical problems, because the market already has enough experience in storage and transportation of LNG (Bech, 2011). Now as LNG becomes interesting to use as a fuel for ships, new technological challenges in bunkering activities arise. How will this activity be conducted? To provide more detailed description how this can be done, the process ‘execute bunkering activities’ in Figure 10 has been detailed described in Figure 11.
Figure 11 - Detailed description 'Execute bunkering activities' in logistical chain of LNG (TEN-T, 2011)

This figure shows the steps that are involved in the bunkering activities from terminal to vessels. Here the first step is the transportation of the LNG from the receiving terminal to the intermediary terminal. This can be done by truck, bunker feeder, a vessel or gas pipeline. From this point, several options are possible: first LNG can be stored offshore (transportation can be done by vessel or barge), secondly LNG can be stored onshore (by tank or container) or finally it can be stored on a small scale terminal (Harsema, 2011). Next to this LNG can be transferred to LNG vessels by: bunker barge, bunker vessel, truck or pipeline. The choice between these bunkering options will depend on several factors, like: costs, capacity, lay-out restriction of Ports and demand in the market. Also safety regulation will have influence on the design of bunkering facilities at ports. A detailed description between the relations of important factors is shown in Figure 12.

3.2 LNG VESSELS AND COMBUSTION ENGINES

The infrastructure of the LNG chain has been described in the previous section. The technical level analysis will be extended by presenting the challenges of the vessels that will use LNG as a marine fuel.

Building a new ship using LNG as a marine fuel will cost more than a compared conventional vessels according to almost all actors in the market. The information provided at the small scale LNG conference in Amsterdam by attended actors showed that LNG vessels will be costly compared to conventional ships. This mainly because a LNG vessel requires an expensive LNG storage tank and a new combustion engine using gas as fuel. Besides these two big components, it requires additional systems and design solutions that make the building of these ships more expensive (Baumgart & Olsen, 2010). Specific numbers cannot be given, hence these types of detailed figures about cost differences are hard to find in the literature (some master students have conducted cost comparison analyses between different fuel options, but mainly used assumptions regarding investment costs (Alvestad, 2011)). A reason for this can be the fact that companies don’t want to share all their information concerning the costs of their services and products. Also they maybe want the market to believe that a LNG vessel is much more expensive than a conventional vessel. The same issue rises regarding the LNG storage tanks on the vessels. No regulatory framework or standards currently exist according to interviewee
working at a shipbuilder in the Netherlands for the design of vessels using LNG as a marine fuel. This is also confirmed by literature from Swedish universities: the positioning of the tank can lead to more or less storage place for goods which are transported (Dahlstrom & Lundh, 2011). But here no information can be found regarding the possible costs of placing the storage tank at different levels of the vessel (on open deck or the ship).

Still a comparison can be made between different marine fuel options (LNG, HFO and MDO) based on the prices of oil and gas. Engine firms like Wartsila and Rolls-Royce have conducted cost analyses to give an indication which alternative fuel will be attractive for shipping companies. In the interview with a campaign manager at one of the engine producers he mentioned that LNG engines have a better return on investments compared to alternative HFO and MDO/MGO. This will be presented in section 3.3.

The market players like Wartsila and Rolls-Royse are offering different types of gas engines for future LNG vessels which will be able to meet the TIER 3 emission requirements. Rolls-Royce offers lean-burn gas engines which they call the Bergen gas engines. These engines are available in gas-electrical and gas-mechanical applications. “The electrical types require additional investments cost due the electrical system which are required. The mechanical engines require more space in the ship for additional engines” (Baumgart & Olsen, 2010). Besides these types of engines, Wartsila offers dual-fuel (DF) engines using different types of fuel alternatives: LNG, MDO/MGO). These engines run either on gas or on diesel (depend on the engine mode). The DF engines require additional storage spaces in the vessels, because they need additional tanks to store different marine fuels.

The advantage of a DF engine is the fact it doesn’t depend on one fuel. When the infrastructure for bunkering facilities are at the same level all over Europe, these vessels can use diesel when LNG bunkering is not possible. This is expected as a great advantage compared to vessels using only one type of marine fuel. However some experts on the conference in Amsterdam mentioned possible drawbacks for these kinds of engines: the low quality of LNG, which depends on the methane number, can cause knocking effects (van der Gaag, 2011) (Levinsky, 2011). This means that a secondary ignition in the engines could lead to damage. The quality of LNG is here important, because the import of LNG from different countries have different LNG quality. LNG with a methane number below 80 is categorized as low quality. Contrary to this effects, the lean burn gas engines doesn’t have the knocking problem, hence they say the engines can deal with methane numbers from 60. This was mentioned by the interview with the engine producer and they expect that the performance of the engines will become still better in the future (EngineProducer, 2012).
In this section the different technical levels of the system was shortly described. In Figure 12 a causal diagram of the system has been presented, summarizing the relations between the important factors in the system. This figure shows how these technical subcomponents, like: infrastructure, LNG vessels, engines and capacity of Ports interrelate. This analysis didn’t capture all the factors, but shows only the important and frequently mentioned factors in the literature and interviews. This diagram helps to present the technical and economical mechanism of the LNG market and helps to understand why for example the chicken and egg problem exists in this case. One of the purposes of this research is to understand how the actors behave in the system and how they will influence the system. Thereby the causal diagram will help to understand the possible effects of the strategies different actors can execute. For example: what can be the consequences of an increase of the LNG price in the market. As can be seen, the LNG price has direct effect on the fuel costs of a shipping company. Higher fuel costs will lead to higher operational costs and in the end higher costs to use LNG as marine fuel. This will finally lead to lesser ships on LNG in the system. This short examples show how changes in the system can effect choices of actors in the market. This diagram will be extended with institutional factors and actors in section 3.5.

3.3 LNG COMPARED TO HFO AND MDO/MGO

The technical components involved in the LNG system are presented but the industry doesn’t have LNG as the only alternative to satisfy the TIER 3 requirements in 2015. Shipping companies can choose also for marine diesel/gas oil (MDO/MGO) or heavy fuel oil (HFO) with scrubbers (SCR). The main question in the market is which of the alternatives will be the most used one in the shipping industry. Will the shippers mainly choose for HFO or LNG? Or will MGO will be the mainly used marine fuel for the coming 10-20 years? The three marine fuels have each their own positive and negative aspects. However the main decisive factor will be the cost.
required to use the marine fuel, according to interviewees of bunkering operator B, research institute and the shipbuilder. Before these economic analyses will be shown, the negative and positive aspects of the three marine fuels will be described shortly.

Using MGO will not require retrofitting of the engines. Also no new storage tanks are required. Therefore the investments cost is not high. However MGO will not fulfill to the TIER 3 requirements and it needs additional SCR (Selective Catalytic Technology) (Kullas-Nyman, 2011).

HFO with scrubbers has the advantage that no new engines and infrastructure is required to operate on conventional fuel. The use of scrubbers also has disadvantages. New installations are needed to distillate the sulphur as well as the waste produced by scrubbers. The question remains how this waste will be regulated at the Ports because no regulation and practices exist for now (BunkeringOperator_B, Director, 2012). Similar situation exist with LNG, because no infrastructure is available to bunker LNG to vessels. Also LNG requires additional investments costs for new engines and storage tanks for fuels. Therefore the investments cost will be high, but the expected operating cost will be low. To make a comparison between the three fuels, several companies have conducted economic analysis. Thereby they have mainly taken investments and operational cost into their analyses, but also additional costs needed for infrastructure. These analyses will be presented now.

3.3.1 **Economic perspective Wartsila**

During the conference in Amsterdam the engine producer Wartsila presented figures comparing MDO, HFO and LNG based upon different criteria. They looked at the payback time of the investments and the net present value during 10 years of operation. From these analyses it can be concluded that LNG will be the most attractive marine fuel for the shippers.

![Figure 13 - Payback Time of three marine fuels (Bui, 2011)](image)
Figure 13 presents the payback time needed to earn the additional investments needed to use scrubber technology and LNG. Here it can be noticed that the investments needed for LNG will be lower than scrubber technology. Figure 14 shows the result of the net present values where 10 years of operations are taking into account. This analysis shows also that LNG will be a financially better option than scrubber technology.

3.3.2 **Economic Perspective Rolls-Royce**

Rolls Royce has conducted the same analyses, these cannot be compared one to one, because different types of engines have been used and also different assumptions are made. These analyses are shown just to see which alternative fuel is the attractive one in the different analyses of market players. Thereby conclusion could be made about how actors see LNG in comparison to other alternatives and what the potential will be for the future.

Figure 15 show the comparative fuel cost between the HFO, DF (Dual Fuel) and LNG. This figure has been obtained from Rolls Royse. Here the cost made in years are presented and it can be noticed that LNG as marine fuel will be the interesting marine fuel for the coming years. Also in this figure the DF engines cost more than
the LNG engines. This is remarkable because Wartsila is the rival company producing DF engines. It can be mentioned that these figures are developed to strengthen the market position of both firms. However in both analyses, LNG is estimated as the best solution.

### 3.3.3 Economic Perspective EU Study

In a draft feasibility analysis of the EU (TEN-T b, 2011) HFO, MGO, LNG and Dual Fuel are compared in four different scenarios for four different ships. These scenarios are based on different prices of fuel. Also the new build ships and retrofitting of the current ships has been taken into account. As a result they presented the payback times of the three different marine fuels in four different scenarios, looking to retrofitting and new ships. The results are presented in Figure 16.

This analysis is much more extensive and takes different characteristics of the market into account. The different market, new and retrofitted vessels and different options are varied within the analysis. Thereby this analysis provides more insight than the conducted research by Wartsila and Rolls-Royce. Also the different costs, like: operational costs, investments costs, fuel costs and additional infrastructure costs has been taken into account (Figure 16).

![Figure 16 - Illustration of payback time in different fuel price scenarios compared to MGO (TEN-T b, 2011)](image)

The conclusion here which can be made is that new builds of ships by all of the different alternatives will be more attractive. Beside this conclusion, also the payback time is shorter by LNG and DF compared to scrubber technology (The Ministry of Transport and Communications Finland, 2009). HFO becomes interesting if the price for LNG will be high. In Figure 17 the final cost comparison has been given. In all scenarios, MGO is the most expensive marine fuel. LNG will be the most attractive one.
Different studies have been shown from different actors in the market. These were retrieved by conference presentations or literature. However, the same question has been asked to the interviewees for this research. Among all interviewees, the following question has been asked: “which marine fuel will be the most attractive one for shipping companies?”

3.3.4 PERSPECTIVE INTERVIEWEES

The answer to this question has been given by expectations from the interviewees’ point of view and experiences they have in their businesses. Table 3 will show their expectations. This empirical data must not be seen as a fact that their expectations will occur, but it complements the economic studies which have been conducted by other parties. Besides the economic perspective, the comparison is made, the interviewees have looked to the overall complex environment in which LNG, HFO, MGO/MDO, and DF will be active. They judged based upon their experiences and tacit knowledge which they may not be able to explain in figures or graphs.

Table 3: Expectations interviewees regarding future marine fuel

<table>
<thead>
<tr>
<th></th>
<th>HFO SCR</th>
<th>MDO/MGO</th>
<th>LNG</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkering operator A</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship-owner Association</td>
<td></td>
<td>X</td>
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</tr>
<tr>
<td>Research institute</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship builder</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Engineering firm</td>
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<tr>
<td>Engine producer</td>
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<tr>
<td>Knowledge institute</td>
<td></td>
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<td>X</td>
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<tr>
<td>Umbrella Organization</td>
<td></td>
<td></td>
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<td>X</td>
</tr>
<tr>
<td>Ports</td>
<td></td>
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<td></td>
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<tr>
<td>Gas transporter</td>
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</tr>
</tbody>
</table>
Many give LNG and HFO with scrubbers a good chance in the future which will be used as marine fuel in the Netherlands. For them it’s also uncertain which alternative will be the favorite. Interviewee of the ship-owner association which represents the shipping companies in the Netherlands says diesel will be used despite the high fuel cost of diesel. The main reason for this will be the fact that the market is very uncertain and unreliable for the shipping companies. Therefore they will choose for the most trustable fuel option. The information gained from the literature show that LNG will from an economic perspective the most attractive option to fulfill the new emission requirements. The experts, on contrary, have divided opinions in which scrubber technology and dual fuel application have also a good potential in the market. These expectations are not only from an economic perspective, but taking also other factors in the system into account. As can be concluded, no exact number can be given for example about the investment cost for a shipping company in the Netherlands. Each company has their own characteristics and operates in different shipping markets. Therefore it’s hard to present the costs of different fuel options, specific for their situation, in the future. This falls out of the scope of this research.

Another important point which can be made is that firms providing SCR technology do not lobby as much as the LNG lobby in the market. The market players are more involved where LNG is tested, compared to HFO and MGO. However in their minds and analyses, LNG has been taken as a starting point. Many conferences are organized for LNG.

The different calculations to compare the marine fuel options of the companies are caused by the uncertain LNG price. This leads therefore to missing and unreliable business models for the shipping company to support their strategy in the future. This will be more elaborated in chapter 6. The technical mechanism of the system show that lots of factors are involved which makes the LNG system very complex. The uncertainties of the factors like costs and availability of bunkering facilities, engine performances and LNG prices leads to an uncertain costs calculations of the different fuel options. But these uncertainties are not only caused by the technical mechanisms, but also caused by institutional mechanism of the system. This will elaborated in the next chapter.
4 THE INSTITUTIONAL MECHANISM IN THE LNG SYSTEM

The technical level in the LNG casus is described in the previous chapter. Many studies have already done it in detail but new empirical data has been added by insights gained from interviews. As this part will look at the institutional side of the LNG casus, first the theory behind institutions will shortly be introduced. This will be help to understand the institutional part of the analysis within the TIP framework. The current available literature captures some highlights regarding legislation and standards about LNG as fuel for vessels. However the interaction and effects of institutions on technology (and vice versa) is missing. This chapter will not come up with a new institutional design for the LNG casus, but it will describe the institutions in more detail related to technology. This analysis will help to structure the literature and to create more insight between the interactions between the different levels in the system. The theory used for DANA (Dynamic Actor Network Analysis) will be applied. This method combines the stakeholder analysis with the technical mechanism of the system (Bots, 2008) (Figure 12). Hereby the effects of the behavior of the actors in the system can be explored. The program applicable for DANA will not be used, because the scope of this research is limited. The institutional analysis will later be used as input for the socio technical scenarios (STS) in chapter 5.

For conducting the institutional analysis both literature and interviews has been used. The interviews have been conducted with experts in the market. Several private market players, knowledge institutions, and governmental bodies have shared their knowledge regarding LNG. From these interviews new information has been gained and compared with the available literature. The gathered information from three conferences has also been used (Flevum, 2011) (HME, 2011).

4.1 DEFINITION OF INSTITUTIONS

First a description has to be given of institutions. In the literature many definition are valid but in general this can be formulated: Institutions are rules. Social institutions are rules structuring behavior, what sustains stable and recurring patterns of behavior (Figure 18). By rules the following can be intended: routines, procedures, conventions, roles, strategies, organizational forms, beliefs, paradigms, codes, cultures (March & Olsen, 1989).

Scharf describes institutions as (Scharf, 1997): “system of rules that structure the course of actions that a set of actors may choose”.

In complex technical systems, like LNG as a new fuel alternative for ships, many parties are involved that need coordination. These technical systems are not working by themselves, but need ‘rules’ that guide and coordinate the behavior of actors (Koppenjan & Groenewegen, 2005). This coordination can be done by law, arrangement or other rules between actors.

The definition has been made clear now and the following step will be the mapping of the institutions which play an important role in the introduction of LNG as fuel alternative. Therefore, the following questions will be answered:

![Figure 18 - Interactions between Institutions and Behavior](image-url)
a. What institutions are at work?
   i. Identifying institutions
   ii. Describe and sort them in categories

To answer the first question, the four layer model will be used (Figure 19). This model specifies each type of institution at different levels and how they relate to each other. This model is a modified result of the three and four layer models of Williamson. The four layer models differs in two respects: actors and their strategies are added to the transaction approach. Secondly, this new model allows the interactions between the levels (Koppenjan & Groenewegen, 2005).

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**Figure 19 - The four layer model**

The institutional framework which currently exists in the LNG case will now be exposed. Hereby, the four layer model will be used. Figure 19 shows there are four levels in which institutions can be categorized. Sections 4.2 will present Layer 1 of the four layer model. The actors and games in the system and the important alliances will be shown. Section 4.3 will present Layer 2, which includes the relations between the actors in the system. Section 4.4 will present Layer 3 of the mode, which include the formal institutional environment like law and regulations. The last layer will be dealt with in section 4.5, where the culture of the system will be analyzed.

Finally section 4.6 will show how the institutional and technical part of the system interrelates and effects on each other.
4.2 THE POSITION OF ACTORS IN THE MARKET

The situation in North Europe has been analyzed now. This research will continue with the basis of this research: analyzing the actors in the Netherlands regarding LNG as fuel. To do this, a stakeholder analysis will be conducted. This analysis will provide the institutional mechanism in the shipping market and will show how the game between the actors is played now. Next to this, the possible effects of the actions of actors in the system will be shown. Simultaneously the situation regarding the development of LNG as marine fuel in the Netherlands will be given.

To conduct the stakeholder analyses, literature and interviews of market players has been used. Also conferences have been visited to gather information. Not all actors have been interviewed, due to the scope and the time constraint of this research. Also it must be mentioned that many market players were approached, but not all could be interviewed. This could have several reasons like the confidentiality issues of the firms which will protect their strategies in the future. Another reason could be that some didn’t have plans regarding LNG or others didn’t have researched this topic enough at this stage.

The introduction of LNG as marine fuel will develop in a complex environment in which different actors will have strategies and influences in the system. Not only the environment will influence the actors, but they will also influence each other to find a desired position in the market. The stakeholder analysis will have several steps which will provide a good understanding of the institutional mechanism in this system.

First an impression of the involved actors will be given. Then, the formal relations between the actors will be mapped. Thirdly the problem perceptions, goals and the interests of the actors will be presented. Next, the dependencies between the actors will be shown by analyzing the resources of each actors and their involvement regarding LNG. Finally the effects of the institutional mechanism (presented in the four layer analysis) on the system will be given.

4.2.1 THE MAIN ACTORS IN THE MARKET

To firstly analyze the actors in the market, the value chain of LNG (Figure 10) can be used to structure the first important actors in the system (Figure 20). The first step and second step in the chain is the production of LNG in plants. These plants are generally located in Nigeria, Algeria, Ivory Coast and Norway. No production and liquefaction is conducted in the Netherlands, thereby no involved actors can be mentioned. The third step in the chain is the transportation of LNG to the LNG terminals. This will be done by shipping companies taking the LNG from the production plants to the future LNG import terminals across Europe. An actor which can be mentioned conducted this activity is Anthony Veder (GasTransporter, 2012). Several other actors can or will be able to these activities in the future, but this actor already has experience with LNG. Here it can be concluded that the supply part of the chain is namely handled by actors positioned outside the Netherlands. Looking to the demand part of the chain, the receiving terminal will be the next step in the chain. A difference can be made between private and public actors handling the LNG at the terminals. At this stage the Ports and private actors, conducting bunkering activities to the end consumers, are involved.

The imported LNG will have to be stored at the Ports. This activity can only be conducted at the new GATE terminal which has been realized by the Gasunie and VOPAK in the Port of Rotterdam. Besides these actors, other incumbent market players from the oil industry will try to penetrate this new market, such as: Argos, Shell, Esso, Total which have their own storage locations in the Port of Rotterdam.

Looking at the end consumers in the chain, several actors can be identified. The first group of actors will be formed by the shipping companies. The whole system is based on the actor that will finally decide whether they will use LNG as a marine fuel or HFO with scrubbers or MDO. Another group of end consumers are the local energy companies which can use LNG for the supply of energy to their customers through the gas grid: Essent, Eneco, and Nuon. Also LNG is attractive to use as fuel for trucks. Parties like Rolande and Ballast Nedam
announced during two visited conference that they want to build filling stations for trucks which will be able to use LNG (Flevum, 2011) (Rolande LNG B.V., 2011). Three main markets have been identified, but the focus of this research will be on the shipping industry. This is also a broad market with several submarkets like ferries, short sea shipping, and inland shipping end so on. The potential of each sub market for the use of LNG will be given in a further stage of this research.

Next to the market players active in the value chain, other actors can be identified. First the residents can be identified who are living in the neighbor of the Ports. The safety aspect of LNG is mentioned by interviewees of bunkering operator B, research institute and the ship-owner associations: LNG creates a feeling of fear on the general public and this will influence the behavior of local residents. In Norway people don’t have this fear and here a difference in culture can be noticed. Secondly the national and local government will get involved in the system. These actors will emit the permits which will be required, for example: the building of LNG terminals, or permits needed for transportation of LNG through the inland rivers. Both actors will finally be directed by the EU, who makes international regulations, directives and guidelines (ESPO, 2011).

This new innovative system will require additional services from current and new firms providing LNG as fuel at the lowest possible cost for the end consumers. The motor engine producers and the shipyards will provide new engines and vessels for the shipping industry for example. Interviewees of the shipbuilder, the research institute, bunkering operator A and bunkering operator B all agree that the cost of the engines, the cost of the new ships and the converting costs will have influence on the decision of shipping companies which alternative fuel they will use to fulfill the new emission regulations. Beside the costs, other performance indicators like motor power, lifetime of the ships, loading space will be important when the comparisons will be made between the alternative fuels (Shipbuilder, 2012). During the interview with the bunkering operator b, the interviewee consisted that LNG must be seen as an economic competitive fuel alternative and not only as an emission free marine fuel. In contrary to interviewees of the research institute and the shipbuilder which focused more on the pollution reduction characteristics of LNG. This is an interesting point where can be noticed that market players can have different approaches regarding LNG as marine fuel. Some see it as a pollution free fuel and others sees an interesting marine fuel from an economic point of view.

At this stage, the required knowledge for the end consumers is not enough to base their decisions on. This is an opportunity for consultancy and engineering companies to provide their services to end customers. Also nonprofit organizations like universities, research centers are involved to provide more knowledge regarding the opportunities of LNG for actors active in the market, like: TNO, TU Delft, Holland Innovation Team. Finally the governmental bodies can be mentioned, who are representing the values and interest of associated customers like: NOVE, ESPO, KVNR.
The actors involved in the LNG system have been made explicit. The relations between the actors will be described in the following section.

4.2.2 INTEREST AND GOALS OF IMPORTANT ACTORS IN THE LNG SYSTEM

Beside the relations between the actors in the market, it will be important to know what the goals and interest of each actor. With this information the behavior of the actors now and in the future could be understood better. For each actor the interest, desired situation in the market, the expected situation in the market, the causes of their situation and their possible behavior will be explored in this section.

The European Union has the responsibility to safeguard the air quality within their borders. Therefore the emission regulation will be introduced in 2015. Their expected goal is to reduce sulphur and NOx emission of the shipping industry within the ECA regions. A further goal will be to introduce these rules also in the other seas in Europe. Their core aim will still remain to protect the European shipping industry compared to other industries worldwide. The reason the regulations will be imported is the fact that the air quality in the ECA regions is dramatically poor. In the past the main goal was to stimulate the industries in the EU so the environmental goals were often neglected. To protect the air quality and also the industry they provide new regulations and guidelines. Interviewee of the ship-owner association expects that within the EU more guidelines will follow in the future and the requirements of the emissions will be strengthened. The main issue remains still the implementation of the rules in the industry and if the actors in the market have enough
resources and time to adapt. The administrative complexity and the support of the actors will be additional requirements for the EU, though these are also neglected due the economical downfall in the EU.

The national government of the Netherlands has a similar role as the EU, but they are a step behind in the hierarchical level of the system. They also want a better air quality within their borders, hence the emissions in the Dutch seas are one of the highest within the EU. The main goal will still remain to stimulate the Dutch industries and to keep the Netherlands as one of the biggest logistical distribution center of the European Union. The expected situation is that shipping companies will have financial problems with the new emission reduction requirements, but for now the government has not adopted an active attitude in the market. Interviewee of bunkering operator A addressed the passive attitude of the Dutch government regarding LNG. Another important point he mentioned is that in the future the government could put taxes on LNG. Others think that possibly subsidiaries can be given to overcome the transition to a low emission marine fuel for shipping companies. Also a flexible regulation regarding permits for infrastructure in Ports and location outside the ports can be carried out. This is a possible strategy the government can follow, but they also can remain passive for the coming years.

The ports will protect their core business and try to expand the economic activities in the harbor. Mainly the attractiveness of the Port for national and international companies will be important (Tieman, 2011). Also serving and supporting their current clients at a high is one of their business goals (UmbrellaOrganizations_Ports, 2012). From an economic point of view, the desired situation will be the economic growth in the harbor. However this expansion is constrained by space and guidelines from the EU and national governments. Currently the expectation will be that additional services in the Ports are expected regarding the logistics of LNG or scrubbers for HFO. This is caused by the uncertainty in the market about which marine fuel will be the most successful in the coming decades. Possible strategy of the Ports could be a close cooperation with private market players like shipping and bunkering companies to adapt the current Ports layout to future requirements.

Other important actors are the shipping companies. Their main goal will be to operate at the lowest costs and fulfill to the new requirements within the European Union. The expected situation is that the costs of their operation will increase for the coming decade to adapt their ships for the new regulations. The uncertainty regarding the costs for HFO and LNG as marine fuel makes it hard to decide between the two alternatives in the current situation according to interviewee of the ship-owner association. They are for now in a wait-and see position and try to gain more knowledge from the market. Some shipping companies, like Deen shipping, have converted one vessel which used LNG as fuel. Anthony Veder has also plans to use the boil-off gas of LNG during transportation for their carriers. It remains still uncertain how these firms will adapt their current fleet. The strategies of the shippers are hard to predict, hence during the research none of the shipping companies was prepared to give an interview regarding this topic.

The oil related companies like Argos are trying to develop new services like bunkering and storage of LNG in the future. Their main goal is to expand their business activities and to create revenues in a new market. They expect that LNG will become an interesting marine fuel in the Netherlands, looking at the activities of other actors in the market. Therefore interviewee of bunkering operator A addressed an active attitude in the market and future investments in bunkering facilities. Regardless the low or high potential of LNG as fuel, they will provide bunkering services in the coming years.

The engine producers already have engines able to provide vessels that run on gas. Wartsila bets on dual fuel engines and Rolls Royse has only lean gas engines in production. Here a strategic choice has already been made by two of the companies. Both firms expect that LNG will play an important role in the future and they already adapted their business strategies. Future it can be expected that they will try to cooperate with shipping yards to sell their engines for LNG vessels. At the current time these parties show their products at conferences and everywhere they can to make sure other actors get impressed by them. This will probably continue in the
future and this strategy is not only followed by engine producers but also by other private actors. According to interviewee of the ship-owner association the parties with no risks in their business investments will try to push the market in the desired directions. Engine producers, components suppliers, LNG suppliers are some actors without having risks in conducting their business activities.

The goals of important actors are described, but an overview of the interest and goals of the other actors in the system is presented in Table 4. This table shows shortly the interest and goals of other market players which are not mentioned yet in this section.

**Table 4- Overview goals and interest of Actors in system (input obtained from interviews and literature)**

<table>
<thead>
<tr>
<th>Actor</th>
<th>Goal</th>
<th>Desired situation</th>
<th>Expected situation</th>
<th>Causes</th>
<th>Possible behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification companies</td>
<td>Create more revenue</td>
<td>Setting own standards in market</td>
<td>More LNG vessels to be introduced in industry</td>
<td>Restricted emission and developments of standards and legislation to use LNG as marine fuel</td>
<td>Using market power to make standards international and try to penetrate other services in market</td>
</tr>
<tr>
<td>Infrastructure operators</td>
<td>Realizing filling stations</td>
<td>Operational infrastructure delivering LNG to customer</td>
<td>Problems with standards in beginning phase</td>
<td>No international guidelines</td>
<td>Cooperation with other market players and research centers</td>
</tr>
<tr>
<td>Engineering companies</td>
<td>Expanding services and more revenues</td>
<td>Being experts related to LNG</td>
<td>Difficulties developing new business models</td>
<td>Uncertainty in the market</td>
<td>Cooperation with other market players.</td>
</tr>
<tr>
<td>Shipbuilders</td>
<td>Develop vessels fulfilling the emission requirements</td>
<td>Well known standards for ship design of LNG vessels</td>
<td>Slow developing of standards</td>
<td>LNG as fuel is new, and not all actors believe in success of LNG</td>
<td>Developing ships at the lowest price for the market</td>
</tr>
<tr>
<td>Intermediate LNG terminal</td>
<td>Providing bunkering services for customers</td>
<td>Well-developed bunkering LNG terminals</td>
<td>Unclear regulation will lead to slow start up</td>
<td>Passive posture of other market players</td>
<td>Investments in bunkering solutions</td>
</tr>
<tr>
<td>LNG distributor</td>
<td>Adding new services to current business activities</td>
<td>Distribution of LNG from Terminal to client</td>
<td>LNG will be distributed, but uncertain about quantities</td>
<td>The demand of shipping companies is unknown and uncertain</td>
<td>Monitoring of demand in market and respond simultaneously</td>
</tr>
<tr>
<td>Gas network operator</td>
<td>Secure gas supply</td>
<td>Gas supply independent from Russia</td>
<td>LNG will imported at larger quantities in the future</td>
<td>Gas is cheaper than oil and the energy demand will move more to gas</td>
<td>More arrangement regarding price and quality of LNG from exporting countries</td>
</tr>
<tr>
<td>International bodies</td>
<td>Protect industries and associated clients</td>
<td>Safe and secure shipping industry</td>
<td>Maintaining emission restriction internationally will be hard.</td>
<td>Influential countries like China, USA can stay out of the international rules</td>
<td>Operating as an intermediary body for private and public organizations</td>
</tr>
</tbody>
</table>
4.2.3 **RESOURCES AND STRATEGIES OF ACTORS**

The interests, goals and the relationships between the actors are analyzed. In this section the analysis will be extended by looking at the main resources of the actors in the system. To get more insights about the actors in the system the following aspects will be analyzed:

- Main resources of actor
- Substitutability of actor
- Importance of resources
- Criticality of actor in system

The EU and the IMO have announced the emission restrictions in 2015 and the goals related to 2020. The EU has great economic and political power. For now, the EU has restricted the shipping industry and set up an institutional constrain upon the system. Their main resources has been the given guidelines and regulations. They set up the new rules of the games and other actors will play their games within their roles. Besides their institutional power, they are able to give subsidies to other actors. These subsidies could have critical effects on the actors in the system: actors could undergo positive or negative effects of the subsidiaries. If the EU government strengthens the rules related to emission of sulphur and NO\textsubscript{x}, in which only LNG will fulfill the requirements, actors using HFO with scrubbers and MDO will have real problems. The EU is a critical actor but has a temporary political mandate. On short term the EU parliament could not be substituted except at the time of elections.

The IMO is also an important critical actor in the system. They work on international treaties and safety standards for the marine industry. Also they work on legislation to prevent marine pollution. Their main resource is to adopt legislation. They keep legislation up to date and ensure that is ratified by as many countries as possible. This excludes the authority to enforce legislation and to act like the police. This shows that contrary to the EU this organization cannot change the rules of the game, but only refine or make recommendations (IMO, 2011).

The Dutch government can play a significant role also in this system. Not on regulatory base, hence this is arranged internationally. The government can provide additional subsidiaries for actors willing to invest in emission free marine fuels. Also they can provide adjustment to national rules that can allow private markets operate without different kind of barriers. This actor will continuously change during time hence new elections could allow other ideas entering the Dutch parliament. This could have effects on the overall perspective related to subsidiaries in the shipping industry. In contrast with the government, the Ports don’t have regulatory or economic powers. They can only provide the right circumstances for private organizations investing in bunkering facilities for LNG. In the system this actor is important because the infrastructure for LNG is not available right now. The Ports have the power to realize this with private companies.

Looking to the private companies in the system, they possess other powers in the system. Rolls Royce and Wartsila have the technology to make LNG engines cheaper, emission free and powerful compared to other engines. The shipyards are similar actors in the system with technological power. According to interviewee of the ship-owner associations and the research institute the role of these firms in the system will influence the strategies of shipping companies. These big companies can be substituted by other market parties who will be able to deliver better engines in the market or deliver better ships. For now they are the one with expertise and
developed knowledge based on gas engines. Contrary to this vision, interviewee of the bunkering operator A mentioned that the technology already is mature enough, but the missing of the infrastructure for LNG vessels still remains as an important barrier for shippers to invest in LNG vessels.

The shipping companies are the one with the most important critical power in the system: this actor will decide which marine fuel they will use in the future. The circumstances and the constrained are set up by other market players, but they will in the end make a decision. The shipping industry can be divided in different segments, like: inland, short sea, ferry, cargo and so on. Shipping companies in these segments will have different conditions for making their own choices. Based upon their decision the market will go in that direction. This power gives them a critical position in the system.

The oil related firms who focus now on bunkering facilities for LNG will take also a critical position in the market. They give solution to one part in the chicken and egg problem of the system, namely: enabling infrastructure for vessels. Their power is having the knowledge in bunkering operations, but still this power is constrained by new requirements of standards for LNG. Also they have already an important position in the oil industry, so enough economic resources to invest in new markets.

In the table below, the main critical actors are given according to the interviewees and the actors which can become important in the future.

<table>
<thead>
<tr>
<th>Critical actors according to interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bunkering Operator A</strong></td>
</tr>
<tr>
<td><strong>Ship-owner Association</strong></td>
</tr>
<tr>
<td><strong>Research institute</strong></td>
</tr>
<tr>
<td><strong>Ship builder</strong></td>
</tr>
<tr>
<td><strong>Engine producers</strong></td>
</tr>
<tr>
<td><strong>Knowledge Institute</strong></td>
</tr>
<tr>
<td><strong>Bunkering Operator B</strong></td>
</tr>
<tr>
<td><strong>Gas transporter</strong></td>
</tr>
<tr>
<td><strong>Umbrella Organization Ports</strong></td>
</tr>
</tbody>
</table>

4.3 **FORMAL AND INFORMAL ARRANGEMENTS IN LNG SYSTEM**

Layer 3 of the four layer model includes the formal arrangements in a system. These are contracts, arrangements, covenants and formal alliances between actors. In this section the current alliances in the system will be presented. Also possible future alliances will be shown, which has been asked to the interviewees.

Currently the LESAS Rotterdam project is in progress where lots of actors are involved, like: TNO, Argos, Shell, Port of Rotterdam, NEN, DNV, Cofely, RIVM, Rolls-Royse, GASNOR, Imtech, Gasunie (Research_Institute, 2012). The aim of the project is to supply recommendations for public authorities and industry on legislations and safety practice. Nowadays the safety assessments are conducted at the Port of Rotterdam. They plan to deliver a global supply chain with description on harbor activities and prognoses for volumes frequencies. These studies are mainly conducted by DNV and TNO.

Another active project is the ‘Binnenschip 2020’ (KOEDOOD, 2011). The purpose of this project is to provide inland shipping operators an overview of the various propulsion concepts for different types of inlands vessels and their operational profile. They want to develop new concept, build these and finally monitor the performance of the concepts in three years. The partners in this project are: KOEDOOD, EcoFlow, Wartsila,
Looking to the current projects, it can be concluded that private firms in the system form alliances to bridge the current barriers they face in the market. Knowledge centers operate with private companies to share knowledge and together test cases are developed to get more insights in safety issues and standards needed for LNG (Buthker & Geus, 2011) (Seifert, 2011). Hereby the uncertainties for other market players is tried to be reduced, namely shippers, so they can become their customers in the future. Interviewee of the research institute mentioned that these projects are mainly started to build confidence in the market and to bring knowledge of actors together. Interviewee of the shipbuilder has another opinion about these kind of projects: the involved actors in these projects are not transparent enough towards the market and projects don’t offer the knowledge which provides new insights and are in the interest of others (actors not involved in the projects). Also interviewee of the bunkering operator A underlined his statement.

<table>
<thead>
<tr>
<th>Possible alliance in future</th>
<th>Bunkering Operator A</th>
<th>Ship-owner Association</th>
<th>Research institute</th>
<th>Ship builder</th>
<th>Engine producers</th>
<th>Knowledge Institute</th>
<th>Bunkering Operator B</th>
<th>Engineering firm</th>
<th>Gas transporter</th>
<th>Umbrella Organization Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partnership to realize legislation and safety requirements: TNO, Government</td>
<td>International bodies with legislators (national and EU)</td>
<td>Joint ventures to realize robust logistical chain for LNG</td>
<td>Joint ventures between shipping companies, certifying firms and component suppliers</td>
<td>Confidential</td>
<td>Alliances for realizing legislation and test cases</td>
<td>Shipping companies and bunkering operators</td>
<td>Alliances for safety studies</td>
<td>Creating more demand for LNG</td>
<td>Alliances to share knowledge: building the logistical chain together</td>
<td></td>
</tr>
</tbody>
</table>

4.3.1 RELATIONS BETWEEN THE ACTORS: A NETWORK ANALYSIS

The involved actors in the market are identified. The following step in this analysis will be to map the relations in the market. Hereby a better insight will be given into the game between the actors and the rules in the market. A network diagram is a helpful tool to map the relations between the actors and to show how the relations and dependencies are at the current situation. This diagram (Figure 21) will give a presentation of the current situation and is just a snapshot. The relations and dependencies can differ when looking at the market after for example two years.

The EU and the IMO have decided to implement new regulations with emission restriction for the ECA region in the EU. IMO expects that the new rules regarding sulphur and NOx emission will be internationally accepted in 2020. The EU members and the Dutch government will have to follow these EU guidelines and will have to adapt their national regulation to the requirements. This will have consequences on for example the ADNR (Accord Européen relatif au Transport International des Marchandises Dangereuses par voie de Navigation du Rhin), which now prohibits using LNG as fuel for inland shipping. The regulations can be seen as one of the triggers making the actors in the system think about how they can adapt to the new rules in the game. An international rule is now seen as the starting point of a possible transition from oil to gas using vessels.
Three alternative marine fuels are available providing solutions for the shipping companies. These firms are an important stone in the whole LNG chain and the system. Hence, their decisions will make it clear in the end which alternative marine fuel will be used the most. It is not said that one fuel alternative will be used by all the shipping companies. Interviewee of the ship-owner associations mentioned: the ratio between oil and diesel in the automotive industry can also be the case in the shipping industry. Looking at Figure 21, it can be seen that the shipping companies depend on shipbuilders and Ports in the Netherlands and in Europe. The shipbuilders will provide new solutions for shipping companies in which they can execute their shipping activities at a lower cost than in the current situation. The technical part of the TIP framework showed that new ship design is required to make competitive vessels using LNG as fuel. Here the tanks and new additional systems are required to achieve this. Shipyards have to think about these new requirements and find cost effective solutions for their customers. In this case it is obvious that shipping companies depend on the innovation power of ship builders. Interviewee of the shipbuilder noticed that engine companies and component suppliers were not transparent enough about their products and deliver products for high prices. This was one of the reasons why a LNG vessels cost more than a conventional ship. Also converting current vessels has been mentioned as a solution, but here high costs for shipping companies are involved. The shipping companies will be driven by the fuel option which will cost them the least. Interviewees of the ship-owner associations and the bunkering operator B made an important point in which they conclude that the current ships in the Netherlands are new, so for them it would be very costly to buy new LNG vessels for their business (Ship-owner Association, 2012). The converting cost to LNG will be more interesting for Dutch shippers than the investments required for a new ship. However to finance this became hard during economic drawbacks in the Netherlands and EU.

The shipbuilders like Damen shipyards are in this system depended on engine companies and suppliers of other additional components. The building cost of a LNG ship will heavily depend on the price of the engine and the tanks required for LNG storage. It is obvious that the engine producers will compete on delivering the most efficient and powerful engines to shipbuilders. Now, Wartsila and Roll-Royce have engines which allow using LNG as fuel. If these companies are able to deliver proper engines to shipbuilders at a lower cost compared to conventional engines (which now is not the case), the shipbuilders can deliver attractive LNG ships for shipping companies. The relations between these three actors are very narrow and it will be interesting which engine (dual fuel or lean gas) will capture the market for new LNG vessels. Therefore, engine producers are now very active to promote their engines in the market and try to make alliances with other companies. Another important actor according to interviewee of the shipbuilder will be the classification companies who certify these new ships or ships which will be converted. Hence new ship designs and engines are required, these types of companies will certify the new ships and therefore practice a certain power in the market. The shipbuilders and shipping companies will depend on the standards of these companies. Contrary to this view the interviewee of the ship-owner association said that the IGF code from IMO will be the guide line for the industry regarding standards, but not the standards from certifying companies. DNV is one of them who has penetrated the market and uses their strategic position in different directions. They certify many ships in Norway and have put standards in the industry which mainly are used in Norway. By using their experience and position as a certification organization, they try to put their standards as international guidelines for ships on LNG.

Beside the costs of a LNG vessel for shipping companies, the infrastructure will be another trigger for a successful introduction of LNG as marine fuel. Now there are no bunkering facilities in the Netherlands realized. A.Nobel Zn has announced to provide bunkering activities of LNG for ships in December of 2011 (BunkeringOperator_B, Director, 2012). If no LNG is available for shipping companies, they will not even think to convert or buy new LNG vessels. They heavily depend on actors who can provide them LNG. The first LNG terminal has been realized by VOPAK and Gasunie. At the conference organized by Argos an expert from Ballast Nedam complained about the fact that there is no possibility to get LNG in smaller proportion from the Port of Rotterdam (Flevum, 2011). In the meanwhile Gasunie and Vopak have announced that in 2015 bunkering
services to ships and trucks will be provided (Schuttevaer, 2012). This terminal is built to import LNG for the national gas grid of the Netherlands. Hereby an independent gas supply from Russia can be arranged if needed. The availability of LNG in the system depends on the import of LNG by the Gate Terminal, because the LNG can only be imported at this terminal. Another nearest LNG terminal is located in Zeebrugge. Shortly it can be mentioned that Gasunie and Vopak have an important role in the value chain, but this is not only based on the availability of LNG. Also the price of LNG will depend on the volume of LNG imported and the quality of the gas. In the interview with bunkering operator b and the research institute they mentioned that the price of LNG will be determined at the spot market, but Vopak and the Gasunie will obviously be able to influence the price. If the demand increase for LNG in the market, it will become cheaper to buy LNG from the gate terminal. The working of the system showed that the price will influence the fuel cost of the ship and thereby the operational cost for the shipping companies. The price of LNG will have a great effect on the total amount of vessels which will use LNG as fuel (Figure 12).

The current firms in the oil related industry see opportunities in providing bunkering services regarding LNG. Argos is one of them who want to provide bunkering facilities for their customers in the industry. They have for the coming years (2012-2014) plans to realize LNG bunkering pantons and from 2016 they will be able to realize ship to ship bunkering of LNG (BunkeringOperator_A, business development manager, 2011). Therefore they need standards and permission for these kind of activities. The requirements for ship to ship bunkering are not internationally defined and also on a national level standards and requirements are missing. Argos heavily depends on the development of the guidelines and also on the Ports which gives permits to conduct bunkering activities. To be operational in the coming years, interviewee of the bunkering operator A said that the company cooperates with TNO and the Port to develop the required standards (LESAS project).

On the other side, infrastructure operators of LNG for trucks like Rolande and Ballast Nedam depend on the availability and price of the LNG in the Netherlands (Rolande LNG B.V., 2011). They want to provide new services like LNG filling stations and therefore need LNG in smaller proportions compared to the shipping industry. The price of LNG must also be attractive to execute new business activities for their customers who want to use LNG as fuel for their trucks. Also these companies are missing standards and requirements to develop the infrastructure for the trucks. ISO and PG33 are projects for new standards announced during the small scale LNG conference in Amsterdam, but they are now in a development phase. It can be concluded that actors active in the infrastructure subsystem mainly depends on the gate terminal in Rotterdam and also on the international/national guidelines and standards. The links between the actors in the whole system is narrow and they depend heavily on each other. This makes the system vulnerable to actions of different actors. The following sections will analyze the vulnerability of the system in more detail.
Figure 21 - Network diagram of actors in LNG system
4.4 Formal Institutional Environment of LNG System

Beside the actor’s behavior and their interrelations in a system, also other mechanism influences the institutions of a system. The third layer of the four layer model includes rules, laws and regulations in a system. Therefore the international regulations and guidelines will be presented, followed by the national rules and regulations.

Authorities and private actors nowadays are researching the possibility to make LNG usable as fuel for the shipping industry to fulfill the new emission requirements in the SECA regions. As it is announced, in 2020 these emission requirements will be internationally valid. Using LNG as a fuel will require a new handling of LNG for transportation and storage. Also safety and security measures must be covered by regulations. Because ships are operating worldwide and calling in different ports in several countries, an international regulatory body is needed to guide these operations. The International Maritime Organization (IMO) is an important actor which supports the shipping industry regarding regulations and guidelines. Their main task is to provide the industry with regulations concerning safety, security, technical co-operation and efficiency of ships. (www.imo.org)

International rules and guidelines (TEN-T, 2011)

- **The IMO with its MARPOL 73/78 Convention.** “Global and local regulations regarding sulphur and NOx emissions”
- **The IMO’s Safety of Life at Sea Convention (SOLAS):** “International threaty concerning safety of merchant ships”
- **The Society of International Gas Tanker and Terminal Operators (SIGTTO):** “the purpose of the Society is to promote shipping and terminal operations for liquefied gases which are safe, environmentally responsible and reliable. “
- **The International Group of Liquefied Natural Gas Importer (GIIGNL):** “GIIGNL promotes the exchange of information and experience among its members to enhance the safety, reliability and efficiency of LNG import activities and of the operation of LNG import terminals in particular.”
- **The Oil Companies International Marine Forum (OCIMF):** “Authority on the safe and environmentally responsible operation of oil tankers, terminals and offshore support vessels, promoting continuous improvement in standards of design and operation.”

The national standards vary regarding the equipment for LNG, design of storage facilities and the transportation. An international guideline is missing which can facilitate LNG as fuel for the shipping industry. The current guidelines are applicable for large LNG installations and the transportation LNG as cargo, but not for small scale LNG infrastructure. The mentioned organizations above are currently working to develop standards and guidelines for their own industry, but for now the international guidelines are missing (KVNR, 2011).

Based on literature and the conducted interviews with several market players, it has been noticed that regulations and guidelines are missing in the shipping industry. As it’s hard to present formal institutions which now are not available, the missing institutions will be addressed from now on.

First of all, regulation will be needed for activities when humans are involved: like personnel at ports and on ships working with LNG. Likewise regulation is needed due to safety for the positioning of LNG facilities in the neighborhood of human residents. Another aspect which has to be developed regarding safety: which safety measures are needed for ferries, when people will board/disembark during LNG bunkering? Interviewee of the research institute has addressed that no problems will occur with disembarking of people at ferries. Other interviewees of the knowledge institute and the bunkering operator B still remains pessimistic and they think many efforts in the future is required to develop the needed safety standards during bunkering.
To use LNG as a fuel for the inland waterways, national and local regulations have to be adapted: ‘These actions require port regulations and bunkering procedures standards for inland navigation in the same way as shipping in general’ (TEN-T, 2011). Next to the bunkering between ships and inland facilities at ports, parties are working to make ship to ship bunkering of LNG possible. A draft IGF code contains guidelines related to this bunkering method, but it’s not finalized yet. On the other hand, SIGTTO has document guidelines for ship to ship transfer of LNG, which concludes safety studies, but these guidelines are not globally yet (SIGTTO, 2011). Another aspect that is not mentioned: the design of a ship using LNG as fuel will require LNG storage tanks on the ships. The design issues like the location of these fuel tanks on ships are not been addressed yet. Interviewee of the shipbuilder confirms the standards for ship design are missing right now.

The international organizations are working on safety and standards for LNG related industrial activities, but for now these are in a development stage. These international guidelines will finally be developed into regulations which will be adapted in the whole industry. Followed by this process, national regulations will have to be adapted to these international regulations. De Ruiter mentioned in his study, which he conducted for the port of Rotterdam, several national regulations which will be adapted in the future regarding LNG as fuel and bunkering (de Ruiter, 2010):

- **ADNR 9.2.0.31.1 Construction specifications for sea vessels; machines:** It is only allowed to build-in engines that use a fuel with an ignition point of above 60ºC.
- **Article 6.1:** Port regulations on dangerous substances section 6.

From this point of view, international guidelines and regulation will overrule national laws and regulation and therefore the national laws will be adapted in the future. Because of this hierarchical structure, international organizations that are operating globally will have their influences on national actors. These types of influences and power structure of actors will be explained in the next chapter.

Taking the logistical chain (technical level) into consideration, it’s obvious that the development of infrastructure, ships and the whole LNG logistic chain depends on regulations and guidelines. All of the interviewees confirm that standards are needed for the industry and because these are not valid now, the private companies feel not attracted to invest in LNG. The institutional framework sets the boundaries for the technology that will be needed shipping industry using LNG as fuel. The rules of the game are not clear, which leads to a passive position of actors in the market (BunkeringOperator_A, 2011).

### 4.5 INFORMAL INSTITUTIONAL ENVIRONMENT OF SOCIO-TECHNICAL SYSTEMS

This layer focuses on the informal institutions like codes, culture, norms and values. Based on the literature not much can be said about culture and informal rules in this system. It requires more in depth analysis and a longer experience in the current shipping industry to make robust announcements about culture. For this reason, this layer is not addressed in this research.

### 4.6 RELATIONS OF TECHNICAL AND INSTITUTIONAL MECHANISM IN THE LNG SYSTEM

The behaviors of actors and formal/informal institutional environment have impacts on the technical part of the system. This section summarizes the detected interrelations between institutional and technical mechanism of the LNG system and concludes the chapters 3 and 4 (Figure 22).

The interviewed actors, like the bunkering operator A, the ship-owner associations and the bunkering operator B have complained about the unavailability of standards and requirements in the system. Also interviewee of the shipbuilder has argued that ships depend on the requirements to place tanks onboard or in the vessel. Here, standards constrain the technical design of a future LNG ship. These standards and requirements can be only set up by international organizations like IMO and certifying firms. The interviewees suggest that if these
standards will set up soon, the private actors such as shipyards and bunkering facilitators could progress faster in their business operations. Then, the infrastructure would be realized faster and the end customers in the chain like shipping companies could adapt also their business activities. The interviewee of the knowledge institute stated that knowledge institutions such as universities can only help the industry in sharing knowledge and conducting research (Knowledge Institute, 2012). However the private markets have to invest and take an active role regarding developments of new marine fuel solutions for the industry. This shows that interdependencies between universities, private companies and governmental institutions is narrow and each wait and want to see what the other will do.

Another important point mentioned by interviewees of the ship-owner associations and the bunkering operator B is the fact that when private actors get stimulated financially, the development of technology could speed up. In this case the technology will get more reliable for customers and during this development the price of for example LNG vessels, price of bunkering costs and logistic costs of ports will decrease.

The regulations, norms and legislation from the EU will determine where ports potentially can realize bunkering facilities for LNG vessels. Interviewee of the bunkering operator A suggested that cooperation between the ports and research centers will accelerate the decision for the location of bunkering facilities. Contrary to this vision, interviewees of bunkering operator B and the research institute suggested that private actors can act by themselves first, and then seek for solutions in the market when they face trouble in the implementation of their business. The government is passive in this case and the common vision is that the government has to operate as a facilitator between the companies. Interviewees of the ship-owner associations and the umbrella organization Ports suggested also that at the current stage no comparison could be made between LNG, HFO and MDO as marine fuel. Therefore a delay of the legislation which will be active in 2015 is required for the shipping companies. If most of the shippers decide to choose HFO with scrubbers as an alternative, LNG bunkering facilities will be superfluous. Also the investments in required legislation and infrastructure in the Ports will be not developed.

Another important effect will be the amount of LNG which will be imported by Vopak and Gasunie. This will have some effect on the price of LNG for the vessels in the market. A high price will break the shipping companies invested in LNG, because their operational costs will increase. A low demand for LNG in the market will cause high LNG price, because companies like Argos, Rolande and Ballast will deduct less LNG from the import terminal. At the Small Scale LNG conference in Amsterdam, one expert of Booz & Company suggested that the price of LNG in Norway is fixed and therefore the market can make arrangements regarding the determined LNG price in advance. All actions in the system interrelate with many factors and each strategic behavior of an actor can cause significant effects. Because of these complexity and interrelations, interviewee of the ship-owner association mentioned that all actors in the system act passive and is just looking to what others in the market will do. The trust in the market is according to the ship-owner association for now missing. Also the interviewees of the bunkering operator A and the shipbuilder mentioned this in the interviews.

The engine producers have already realized engines on gas. They are one of the few who don’t have delayed their business activities waiting for standards. Also in their case standards will become important, because the engines have to deal with several qualities of engines, but these standards are not valid. On the conference in Amsterdam, Peter van Gaag of Holland Innovation Team suggested for new requirements for LNG engines. Hereby imported LNG from different countries must be labeled by authorized organizations, so it will become clear in the market what the quality is of the LNG. If such a system will be implemented, this will have consequences for engine producers and the Gate terminal in Rotterdam.

It would be interesting to see what actors will do in the future regarding their position in the market and how their behavior will affect the system. Therefore scenarios will be built to analyze which different future scenarios can occur as a result of behavior and trends in the market. This section has already given a short introduction, but this analysis will be extended in the next chapter.
Figure 22 - Relation institutions with technical system (Input: literature and interviews)
5 THE FUTURE OF LNG IN THE DUTCH SHIPPING: BUILDING SOCIO TECHNICAL SCENARIOS

This research will continue with constructing scenarios using the socio technical scenario’s (STSc). ‘A STSc is a story that describes future developments, making use of patterns and mechanism’ according to Geels (the developer of this method). This method will be used to make recommendation for actors involved in the market and how they can adapt their business strategies for the future (chapter 6). The scenarios will serve as a tool to test the possible strategies for actors in the LNG system. The scenario analysis is a sensible way to present uncertainties in the future. The gained knowledge can be used to adapt business strategies based on these uncertainties. As input for this method, the technical and institutional mechanism from chapter 3 and 4 will be used. First the method will be shortly explained and also the choice for this approach. Secondly, the input for the scenarios and the design steps will be given. Finally the scenarios will be constructed.

5.1 THE METHODOLOGY AND CHOICE

The STSc has been developed from the insights of the field of Science and Technology Studies (STS). “STS emphasizes the interrelatedness between technical and social change and analyses how technology is shaped by social, economic, cultural and political forces as well as how new technologies shape society and the interaction between various actors” (Elzen, Geels, & Hofman P.S, 2002). In the previous chapters the interrelations between technology and social, economic and political powers (institutions) are analyzed. This will be used as input for the STSc. The STSc has been developed from the multi-level framework (Geels, 2010). An outline of the framework will be given, because the framework has been described more in detail in literature (Geels, 2002). The three levels of the method are: the socio-technical landscape; the socio-technical regime and technological niches (Elzen, Geels, & Hofman P.S, 2002).

- **Socio-technical landscape:** “describing processes and factors in society (e.g. cultural developments, climate policy) that affect a wide range of developments.”

- **Socio-technical regime:** “a specific sector of society of interest to the analyst. Regimes describe the interrelation between technology, policy, user preferences, and infrastructures.” Section 2.5 has described this level in detail.

- **Technological niches:** ‘alternative’ technologies that hold a promise to play a role in the regime but that cannot compete (yet) with existing technologies. This is partly an economic issue but it also requires tuning of a variety of technical and social factors including infrastructure requirements, user preferences, policy, etc. In niches, learning processes and interactions between actors are key.”

The relations between the levels are given in the Figure 23. The meso-level comprehends the current regime within the system. In the LNG system the HFO is the current used marine fuel in the industry. According to the theory, the technological transitions will occur in the socio-technical regimes. This can lead to changes on many different aspects of the regime, like: technology, user preferences, networks, regulations, infrastructure and so on. The highest levels consist of slowly changing external factors, which influences the innovations in the regimes. In this system the oil price can be given as an external factor. The lowest levels consist of niches which cause the radical innovation in the system. For example: new engine technologies can lead to more success of LNG fuel compared to HFO with scrubbers.
The mechanism involved in the regime level can differ. “Different mechanism and patterns exist in the theory: like technical substitution, broad transformation, hybridization, niche profilation, forking and so on” (Elzen, Geels, & Hofman P.S, 2002). These theories describe how factors in the regime work and influences each other. In this research both institutional as technical mechanism has been described. For the scenario’s this will be used as input but also the mechanism known in the transition theories.

The reason why the STSc theory will be used is the lack of appropriate fore sighting or scenario methods for innovation transition. Geels describes the following fundamental problems of some scenario methods, like: Delphi method, cross impact analysis, curve fitting and trend extrapolation (Elzen, Geels, & Hofman P.S, 2002).

- “Much attention to quantitative and a lack of attention on qualitative aspects”
- “Assumption that the future will be like the past (extrapolation assumes incremental change without attention for radical change)”
- “Too much focus on specific topics, without looking too broader systems”
- “Scenarios have a macro-bias. The dynamic and outcome depend on macro aspects like economy, environmental awareness, oil price. The logic of scenarios is top down what means that processes on a lower level are determined by macro elements.”

The STSc have deal with these shortcomings and tried to improve the theory which provide guidelines to develop scenarios for innovation transition in different systems. The detailed description of the STSc method, constructed by F.W. Geels, can be retrieved in the literature.

5.2 **THE STSC DESIGN STEPS**

In the previous section the mechanism and patterns which can be used to build the scenarios are mentioned. Now the relevant characteristics of the system must be identified for the scenarios. The following steps are needed as input for the scenarios:

1. Design choices and contours of the scenarios
2. Identifying potentially interesting linkages
3. Analysis of the dynamics of current regime
   a. Regime characteristics, problems, strategies and trends
   b. Landscape factors
   c. Niches: opportunities and barriers
4. Make the scenario
These factors are largely been analyzed and identified in the previous chapters. In the following sections the needed input will be filtered and additionally information will be added to build the scenarios.

5.2.1 **DESIGN CHOICES AND CONTOURS OF SCENARIO**

The purpose of the scenario will be to explore possible transition paths in the shipping industry for the marine fuels of the future. The timeframe that will be used is till 2032 (20 years). The number of scenarios which will be built is 3 in this research. The main distinguishing features between the scenarios will be the following:

- Different trends (Landscape Level): Oil and LNG price, International Policy. The price of oil and LNG is very uncertain in the market (Auer, J; Nguyen, T.L, 2010) (Gascoyne & Aik, 2011). Because the price of LNG and Oil will influence the attractiveness of the marine fuel, this factors will be varied in the scenarios. Besides prices and policy, also the green awareness of end users can change over time. This will be also taken into consideration.
- The dynamics at regime and niche level (variation at social and technologic dimension). The behavior of actors in the market is uncertain. They each have their own interest and goals in the market. Because the institutional mechanism of the system is uncertain, variation will be conducted based on possible strategies of actors. Also varying the technical developments can lead to different future paths in the future. This will also be taken into consideration.
- Linkages between promising transitions.

The main outcome of the scenarios will be the market share of LNG as marine fuel in the future. It’s important to notice that the outcome of the scenarios is not important, but understanding the mechanism and patterns which lead to these outcomes.

5.2.2 **INVENTORY OF POTENTIAL LINKAGES AS PROMISING TRANSITION ELEMENTS**

STSc allows the analyst to change technological features which the existing scenario methods often leave out of scope. To do this an inventory of new links must be made. Geels gives examples of these types of linkages:

- Hybridizations: merger of two options to create a new alternative. In the LNG system the dual fuel engines can be seen as hybridizations between gas and diesel engines (scenario 2).
- Link between technical and political development: In the LNG system new regulations are developed to reduce pollutions and this can linked to the development of gas engines to use LNG as marine fuel.

The linkages between the landscape, regime and niches level will be varied in the different scenarios. Technology will not be the main driver to make the linkages but also other dimension will be part of the analysis. Policies, culture, market and financial dimension will be used to make interesting linkages.

5.2.3 **ANALYSIS OF THE DYNAMICS OF THE CURRENT REGIME**

The next step in the scenario analysis will be to analyze the current system and the dynamics/mechanism of the system. This requires the analysis of problems and strategies of actors (regime level), but also trends (landscape level) and barriers and opportunities of niches (niche level). The mechanism of the system has been presented in chapter 3. Also the strategies of the main actors and the institutional mechanism of the system have been analyzed in chapter 4. Critics of the STSc had announced that the STSc didn’t use a clear method to analyze and structure actors behavior in the system (Geels, 2010). The analyses in chapter 4 provide an example in how institutional mechanism of a system can be explored and be used within the STSc analysis. The insights of both previous chapters will be used as input to write the scenarios. However to extend the information gained from the literature, the opportunities, barriers, potential markets and possible trends are asked to the interviewees. The empirical data has been added to the current available knowledge.
Table 7 - Potential future markets for LNG as marine fuel

<table>
<thead>
<tr>
<th></th>
<th>Ferry lines</th>
<th>Inland shipping</th>
<th>Short sea shipping</th>
<th>Cargo shipping</th>
<th>Coasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkering operator A</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ship-owner Association</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Research Institute</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ship builder</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering firm</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine producers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Knowledge institute</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Umbrella organization Ports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Gas transporter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Bunkering operator B</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table 7 shows that the ferry lines, inland shipping and short sea shipping provide chances for LNG according to the interviewees. By validating this information with the literature, it can be concluded that the information gained from the interviews is similar (Hoogma, Koopman, Kerssemakers, & Ausema, 2009). Another important question has been asked, namely: which important trends do you expect to occur in the shipping industry? The answers to this question are presented in Table 8.

Table 8 - Important trends according to interviewees

<table>
<thead>
<tr>
<th>Important Trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkering operator A</td>
</tr>
<tr>
<td>Ship-owner association</td>
</tr>
<tr>
<td>Research institute</td>
</tr>
<tr>
<td>Ship builder</td>
</tr>
<tr>
<td>Engineering firm</td>
</tr>
<tr>
<td>Engine producers</td>
</tr>
<tr>
<td>Knowledge institute</td>
</tr>
<tr>
<td>Umbrella organizations Ports</td>
</tr>
<tr>
<td>Gas transporter</td>
</tr>
<tr>
<td>Bunkering operator B</td>
</tr>
</tbody>
</table>

The table shows that the main important trend will be the development of the LNG price. Next to price developments others think the development of legislation will have an important effect on the system. Also remarkable is the fact that no one has mentioned alliances between actors as a possible important development in the future. The literature showed also that the price of LNG and legislation will be important and similar conclusion can be made about the gained information from the interviews (Jensen, 2004). Besides
this, also opportunities and barriers have been asked regarding the introduction of LNG as marine fuel in the industry. Each actor has announced the factors which can enable or disable the use of LNG as marine fuel. This is presented in Table 9.

Interesting observation is that there are two different ways in which experts think LNG will have a good potential as marine fuel. The first one depends mainly on the economic aspects of the system, namely the price of oil and LNG. Others see the legislation as a main driver which could enable LNG as marine fuel. This shows that actors in the market will probably adapt their strategies based on these types of views regarding barriers and enablers. This will be included in the scenarios.

The building blocks of the scenarios are described in this section. In the following section the scenario skeleton will be built by combining the landscape, regime and niche developments to initial paths.

Table 9 - Barriers and enablers factors for LNG use as marine fuel according to interviewees

<table>
<thead>
<tr>
<th>Barriers for using LNG as marine fuel</th>
<th>Enablers for using LNG as marine fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bunkering operator A</strong></td>
<td>Absence of standards and legislation for bunkering activities</td>
</tr>
<tr>
<td><strong>Ship-owner Association</strong></td>
<td>Absence of standards for safety. Unknown price of LNG to compare with other fuel alternatives</td>
</tr>
<tr>
<td><strong>Research Institute</strong></td>
<td>Missing safety standards for bunkering and location of LNG infrastructure</td>
</tr>
<tr>
<td><strong>Ship builder</strong></td>
<td>Low prices to provide LNG as marine fuel: price ships, fuel cost</td>
</tr>
<tr>
<td><strong>Engineerings firm</strong></td>
<td>Decrease of LNG import due fracking</td>
</tr>
<tr>
<td><strong>Engine producers</strong></td>
<td>Decrease of LNG import due fracking</td>
</tr>
<tr>
<td><strong>Knowledge institute</strong></td>
<td>High risk for shipping companies&gt; the cost must be lower Absence of legislation</td>
</tr>
<tr>
<td><strong>Umbrella organisation Ports</strong></td>
<td>Legislation and the ‘supply industry of technology’</td>
</tr>
<tr>
<td><strong>Gas transporter</strong></td>
<td>Unclear political positioning</td>
</tr>
<tr>
<td><strong>Bunkering operator B</strong></td>
<td>Infrastructure</td>
</tr>
</tbody>
</table>
In Table 10 the characteristics of each scenario are given. It can be noticed that many scenarios could be written by variation of the used characteristics. This cannot be done within the scope of this research, but in the next section a reflection of the scenarios and possible other interesting compositions of the characteristics will be given. Figure 24 shows also how the different scenarios can be placed, taking the landscape factors of the system into account. Thereby the reader can get a global insight how they differ from each other.

**Table 10 - Characteristics of scenarios**

<table>
<thead>
<tr>
<th>Initial Niches</th>
<th>Introduction of new marine fuel</th>
<th>Hybridization</th>
<th>Introduction of scrubber technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Differences</strong></td>
<td>Focus mainly on gas engines</td>
<td>Hybridization of marine fuels</td>
<td>Focus mainly on adaptation of current technology</td>
</tr>
<tr>
<td><strong>Main similarities</strong></td>
<td>Tightened EU regulation</td>
<td>Slow process of EU regulation</td>
<td>EU regulation</td>
</tr>
<tr>
<td><strong>Drivers</strong></td>
<td>Spot market LNG prices</td>
<td>High LNG price</td>
<td>High LNG price</td>
</tr>
<tr>
<td><strong>Landscape</strong></td>
<td>-High Oil price</td>
<td>-Decrease Oil price</td>
<td>-Decrease Oil price</td>
</tr>
<tr>
<td><strong>Regime</strong></td>
<td>Contracts between suppliers and customers of LNG</td>
<td>Cooperation between suppliers</td>
<td>Non-transparent shipping industry</td>
</tr>
<tr>
<td><strong>Niches</strong></td>
<td>-Better engine production LNG engines&gt;</td>
<td>-Highly developed dual fuel engines</td>
<td>-Waste handling infrastructure development</td>
</tr>
<tr>
<td><strong>Barriers</strong></td>
<td>-Infrastructure and supply industry</td>
<td>-Legislation, -lacking standards</td>
<td>-LNG lobby</td>
</tr>
<tr>
<td><strong>Dominant Networks</strong></td>
<td>inland shipping, short sea shipping</td>
<td>Ferry, inland shipping</td>
<td>International operating routes</td>
</tr>
<tr>
<td><strong>Dutch Policy</strong></td>
<td>Non-financial stimulating policy (legislation, standards)</td>
<td>Slow process of legislation</td>
<td>Stimulating policy (financially)</td>
</tr>
</tbody>
</table>

The market shares sketched in figures 26, 28 and 30 show the growth of each marine fuel over time. The assumption is made that all vessels will fulfill the emission regulation in 2015. In literature nothing is mentioned about the consequences when the shipping companies will not be able to satisfy the emission demands. These figures do not focus on the real shares of the marine fuels in the future, but give a global sketch of the possible developments in the market.
5.3.1 **Scenario 1: Introduction of new marine fuel in the shipping industry**

2010-2020: New sulphur and NOx emission regulation creates tension

Three landscape trends were driving further change in the shipping industry with the high oil prices as the most important one. Simultaneously with new EU pollution regulations, green awareness of the public opinion and worldwide economic crises led to changes in the shipping industry.

Before the regulations in 2016 came into power, changing patterns were visible in the shipping industry. The EU was determined to improve the air quality in the ECA region by reducing the emission of sulphur and NOx. Besides the new requirements in the ECA region, other important developments in other parts of the world could be noticed. The price of oil rated high records because the invasion of Israel, England, France and the United States in Iran. Not only Iran was affected, but the Middle East rolled into a very instable period of time where supply of oil and gas dropped. The high oil prices pushed the shipping industry into other ways to grant their supply for fuel. The price difference in 2015 between MGO in the Port of Rotterdam and LNG was increased till $350 mb/t. The notable price for bunkering of oil in Rotterdam was more than $1100 Mt, nearly at the level of the fuel prices in the year of 2008 ($1200 Mt). Combining the high oil price with the new regulations in 2015, the industry moved strongly to use gas as fuel. Norway was one of the countries were 20 % industry used LNG as fuel. Same developments could be noticed in other parts of Europe.

In the Netherlands, Gasunie and Vopak had increased the supply of LNG in the Netherlands. Shippers used mainly heavy fuel oil for their business operations, but this fuel was not qualified to fulfill the new requirements of the EU. The market between 2012 and 2015 was very uncertain. The new requirements and the economical drawback in that period, made the perspectives for shippers not promising. The uncertainty rose because the market provided three different marine fuel options for shippers to give an answer to the new emission regulations. Adaptation of the ships, based on HFO with scrubbers, LNG and Dual Fuel would cost a lot
in the Netherlands was very new, the choice between the alternatives couldn’t be made. Also the fact that the marine fleet in the Netherlands was very new, purchasing new vessels wouldn’t be a solid solution. The average payback time of investments for scrubber technology to use HFO was nearby 2 years. The expected payback time for LNG retrofitting was below 1.5 year at that time. Also the expected net present value for 10 years of operation, LNG was more attractive than HFO with scrubbers (12000 k€ - 8000 k€).

Current engine producers tried to increase their market share by introducing new engines which could fulfill to the new sulphur and NOx requirements. Rolls Royce had introduced gas engines contrary to Wartsila who had introduced dual fuel engines and also scrubber technology which made the use of HFO interesting. These alternatives mainly competed on costs. HFO and LNG were the interesting options, but each alternative had their own problems. In that period, no bunkering stations were available to provide LNG for ships. On the other side, it was unknown how to deal with the waste of HFO which came from the scrubbers. The technology of both option ware mature but both were not fully tested in the industry. This made the market for the shipper unreliable.

The bulk industry had also interest into the developments of LNG. The handling of gas became interesting because the increasing demand in gas. Storage tanks, logistic chains were organized in the Port of Rotterdam and Amsterdam to deliver LNG for end consumers. Parties like Argos, Vopak and A.Nobel facilitated bunkering services for LNG vessels. The legislation was adapted and the Dutch government eased the legislation for the handling, storage and transportation of LNG. These actions of the government made the use of LNG easier. The high oil prices pushed the shipping companies to try LNG and in the end of 2015 some inland shippers had adjusted their engines to use LNG. Besides the high oil price, the emission reductions which can be achieved with LNG are more compared to other fuel options. MGO needed additional technology to fulfill the <0.1% sulphur requirements in 2020. Also the new bunkering services provided by the incumbent oil companies, made LNG an attractive option. The gas engines became more efficient and reliable which made the industry more incline to use LNG. Mainly inland shippers adapted the engines of the ships to use LNG. Alliances were formed between gas engine developers and shippers. They provided cost competitive engines for the shipping companies, in return these companies would use only gas engines for their ships. Also bunkering actors made agreements with the Gate Terminal so the price of LNG wouldn’t be uncertain for the shipping companies. The price was decoupled from crude oil and related to heavy fuel oil price, which made the LNG price more reliable. The uncertain aspects in the market were made gradually certain which resulted in a positive image of LNG as fuel. After the introduction of the emission rules, the use of LNG as fuel by inland shippers increased from 5% to 15%. The availability of bunkering infrastructure and the price certainty of LNG provided the shippers reliable circumstances to use LNG. The development of price, availability of infrastructure, the introduction of new legislation and the reliable performances of the engines made LNG more interesting for shippers in the Netherlands. However, still MGO was favored despite the high oil prices. This mainly was caused because the infrastructure was not well developed and the investments cost for LNG were high compared to installation of scrubbers.

Other industries, like the distribution sector, adapted their trucks to use LNG as fuel. Ballast Nedam and Rolande B.V. provided new LNG filling station for their customers.
2020-2030: Expansion of LNG as marine fuel in Netherlands

The introduction of the sulphur and NOₓ restriction in the Baltic and North Sea had been extended to the Mediterranean area in 2020. Also the regulations were expanding to international seas, where IMO was one of the driving forces. They had provided new supporting guidelines and standards for associated countries. International covenants were established so the industry had to globally adapt their business operations within emission regulations. The green awareness in Europe to be less independent from fossil energy supplies was growing and this flipped gradually over the globe, especially in the USA.

The alliances between engine companies and shippers became stronger and different cooperations were set up. The gas engine producers delivered better engines which had a longer running time and lower maintenance costs. Also the storage tanks of LNG on ships were better designed which provided more loading space for the shippers. The safety regulations were already set up by the international governmental bodies. Also standards for design of the ships and locations requirements were developed. This process was accelerated by the cooperation of certifying firms. This cooperation led to spread of the standards internationally and provided clear institutions regarding LNG. The tightened EU regulations regarding the percentage of NOₓ and sulphur which must be below 0.1 % of the marine fuel, caused the need for additional systems to reduce the NOₓ pollution of MGO. This development caused also a movement towards the use of LNG.

In the beginning the inland shipping industry was mainly attracted to LNG. After the regulation and standards regarding safety of LNG bunkering and storage was internationally spread in 2020, the market of ferries came as a new customer for LNG. Ferries operating at Texel and at the North Sea to England introduced new LNG ferries. From the new ordered vessels of this sector in 2020, more than 70 % of the new build was LNG fuelled. Because the operating lines of the ferries are known in advanced, the bunkering infrastructure could be
realized at lower cost. Here also starts up of cooperation were set up between Argos and ferry line shippers. In this perspective, the demand and the supply of LNG were arranged in advanced by alliances between actors. Also the local residents get trusted with LNG in time because of the campaigns released by the Ports. In the early phase of the developments of LNG storage locations, the local resident protested against this. Mainly because they had a programmed fear related to gas. This changed gradually when the use of LNG was more incorporated and the public awareness companies were held by the local governments. These developments leaded to a good infrastructure for LNG in the Netherlands. LNG was delivered for lower prices than HFO and MGO, because the oil price was still not decreased after the war in the Middle East. Also new regasification plants were realized and announcements were made to be build new ones. By the end of 2035, Europe would have nearly 125 regasification plants. These perspectives influenced the prices for LNG. The prices for LNG were dropped the € 700 per ton barrage and expected was a price between € 600 and €650. These price developments and the growing locations for bunkering leaded to short sea shipping operations which used LNG as fuel between member states in Europe. In the beginning of 2026, the first LNG vessels operated between Norway and the Netherlands. The shipping companies had the certainty to bunker LNG in other countries which made the use of LNG in short sea shipping became more interesting. By the end of 2029, the short sea sailing routes at the North Sea and Baltic Sea area were for 25 % occupied by LNG vessels. These higher volumes could be reached because the converting of current vessels into LNG vessels was cheaper than in the earlier phases. This was unachievable in the beginning, but the increased demand in the shipping industry made it possible to deliver LNG engines and components for lower prices. The payback time of the investments of shippers could be earned sooner. The number of the amount of LNG vessels was still low compared to MGO in the Netherlands because the Dutch fleet had a very young shipping fleet. After 2025, when the ships were at the nearly at the end of their lifetime, the purchase of LNG vessels became more attractive. The main barriers for LNG were not valid anymore and by the beginning of 2030, the inland shipping industry had more than 30 % LNG operating on vessels. Nearly 50 % of the new ordered vessels were LNG driven. At the latest research conducted by the end of the 2029, the expectations were that LNG would become the most used marine fuel in the short sea market in the North-West European area.

![Figure 26 - Global market share (%) marine fuels in Dutch shipping industry till 2030](image)

5.3.2 Scenario 2: Hybridization of the shipping market
2010-2020: The shipping companies move up to use MGO as marine fuel
Three landscape trends were driving further change in the shipping industry with the high LNG prices as the most important one. Simultaneously with new EU pollution regulations, green awareness of the public opinion and worldwide economic crises led to changes in the shipping industry.

Before the new regulation came into power by 2015, the shipping industry was adapting their business strategies to fulfill the new requirements. LNG became an important alternative for the shippers as marine fuel, but around 2016 new signals were notable. The nuclear disaster in Japan led this country totally change their energy supply. The Japanese government decided to change their nuclear power energy supply by using gas as main energy source. Liquefied gas was a lucrative energy source which could be transported from the Middle-East to the far East-Asia. New important LNG terminals raised and other neighbor countries followed the same patterns. By end of 2020 nearly 250 regasification terminals were realized in Asia. Also another 200 plants were expected to be finished before 2030. The Japanese paid a higher price for gas, which made the LNG exporters mainly focus on the East-Asian market. The LNG spot prices in Japan and Korea were near the $20 mmbtu. In the USA (Henry Hub) the price was nearly at $3 mmbtu. The price paid in Europe was below the $10 mmbtu, but the higher demands in Asia caused an increase to $12 mmbtu.

In the Netherlands the shipping companies choose mainly MGO as marine fuel to fulfill the new requirements. Some shippers had adapted their ships and engines to use LNG, but the lacking infrastructure to bunker LNG was one of the problems. The standards and safety requirements needed to realize a good infrastructure was lagging behind. Not only in the Netherlands, but also in Germany and Belgium the bunkering facilities were not available everywhere on the Ports. Another important development was that the engine companies and components suppliers for LNG delivered high prices to adapt the current vessels of the shippers. During the economic drawbacks in that period, the investment cost to use LNG as marine was not lucrative. The payback time of the investments was calculated between the 5 a 7 years. Compared to the needed investments to use MGO, this was not acceptable for the shippers.

The Dutch government was too inactive in changing the needed legislation. Till 2015 it was forbidden to use LNG as a marine fuel for inland shipping. The safety studies to map the risks of LNG were carried out in 2014. Also studies for standards of LNG bunkering and ship designs were proceeding very slowly. The market for LNG as marine fuel was very unreliable and very costly for the shippers.

The lacking demand from the shippers for LNG lead to low LNG volumes in the Netherlands. The engine producers delivered gas engines but these couldn’t be developed further to increase efficiency and to create economies of scales for others. Also bunkering operators of LNG were not highly interested to provide their services because the demand in the market stayed low. No high LNG volumes could be created and this led also that the LNG price remains higher than the market player firstly expected.

The operational cost to use MGO was higher than LNG because of the higher fuel costs. The shippers paid more than €1000/ton MGO compared to a price of €800/ton for LNG. The uncertainties regarding bunkering of LNG and high investments cost for tanks and engines made the shippers choose mainly to use MGO.
2020-2030: LNG slowly competes with MGO

Internationally the development of standards and legislation for bunkering and storage of LNG was fully developed. New LNG import terminals raised in Belgium and France. The LNG was decoupled from the oil price and this lead to a decreasing LNG price in the European market. Despite the high demand in East-Asia, the LNG prices slowly dropped in a spot market situation in Europe. The European economy expanded and the demand for gas as energy source increased. The demand for natural gas in North-West Europe expanded from 440 bcm per year in 2010 to 540 bcm per year. Before 2016 the prices were between €850 and €950 per ton LNG. In 2020 it was possible to get LNG for €700 ton. The high MGO prices made the shippers think one more time to use LNG for their vessels.

In 2020 the Dutch government had adapted the legislation concerning the use of LNG for inland shipping. New developed designs and engines which had been developed after 2015, made LNG vessels more attractive for their business. Because the MGO prices remained above the € 1000/ ton, they changed their focus on LNG vessels. After 2025, the current Dutch fleet was more than 15 years in operation and this made the shippers think about their future vessels. By then, the ferry lines had converted their vessels to use LNG by copying the experiences from Norway. Because these shippers had a well know operational routes, bunkering facilities could easily be realized. These companies didn’t have the uncertainties that they couldn’t bunker LNG during their operations. In the end of 2025, 40 % of the ferry operators had converted their vessels to use LNG and new orders were made for new LNG vessels (new orders: 60 % of total ferry operators). Also the safety studies and standards which were developed after 2020, made this market more reliable.

The market became more trusted with LNG use and technology. The uncertainties regarding safety and bunkering of LNG were not valid anymore. More LNG vessels were ordered in neighboring countries. In port like Hamburg and Antwerp bunkering of LNG could be realized. The market became interesting also for inland
shipping and short sea shipping. The price of LNG dropped to €700/ton so this was very attractive for shipping companies. The investments needed for conversion of vessels was lower than in 2015, because the supply industry of engines and components delivered services for lower prices. The payback times of new investments dropped from 5 years to nearly 2 years. This perspective made the shipping companies to make test vessels on LNG.

On the Rhine and other rivers in Western Europe bunkering facilities for LNG were valid. These countries had realized import terminals for LNG to secure the gas supply, because the known conflicts with Russia and Ukraine in 2010. These import terminals made the LNG volumes in Europe grow and this offered market players to make business out of it. The current market players in the oil industry focused more on storage and distribution of LNG. This guided oil incumbent oil companies to enter new market and provide new services. From 2020, bunkering facilities all over Western Europe raised and the availability of LNG was not a barrier anymore.

The decreasing LNG prices as marine fuel and the availability of bunkering facilities made the shippers think twice about the future. The vessels were near their end of use and new opportunities were notable regarding the use of LNG. Near 2029 from the inland shippers in the Netherlands nearly 30% had ordered new LNG vessels which would be in operation after 2032. Also nearly 20% of the inland shippers had announced to adapt their vessels to use LNG. The shippers mainly choose to use duel fuel engine which could use both of the marine fuels. These engines reduced the uncertainty that shippers couldn’t bunker LNG in countries where the infrastructure was not fully developed. Also these engines gave more trust to the shippers which could use their vessels out of Europe. Mainly the inland shippers were attracted to LNG, because the infrastructure for LNG bunkering in Belgium, France and Germany was available. The short sea market was also interesting, but not all the countries in North Europe (except Norway) had a solid bunkering location for LNG vessels.

![Global market share (%)](image)

*Figure 28 - Global market share (%) marine fuels in Dutch shipping industry till 2030*

### 5.3.3 Scenario 3: Introduction of Scrubber Technology

**2010-2020: The EU NO\(_x\) and sulphur regulation becomes international**

Three landscape trends were driven change in the shipping industry with the high LNG prices as the main driver. Secondly the strengthened EU emission regulation and the economical drawbacks in Europe leaded to changes in the shipping industry.
The emission regulation announced in Europe in the ECA region made the shipping industry explore the opportunities to adapt their business which could fulfill the new requirements. The incumbent marine fuels, namely IFO and HFO, were polluting more sulphur and NO\textsubscript{x} than allowed. An alternative option was the use of LNG, HFO with scrubbers or MGO. Before 2015 many studies were conducted to analyze which marine fuel would be the cheapest alternative for the shippers. Test cases (different engines types, market segments and assumptions) showed that LNG would have an average operating income (10 years) of 12000 k€ compared to an operating income of 8000 for HFO with scrubbers. Investments needed to use LNG were nearly 7000 k€ and for HFO with scrubbers nearly 6000 k€. To use MGO it was only needed to have additional investments of 4000 k€. In this perspective MGO was an alternative solution for shippers fulfill the new requirements. But the fuel costs for MGO were higher than the use of LNG or HFO as marine fuel. The price of MGO was in 2014 at a level of 1000 per ton, compared to € 600 per ton HFO and € 800 per ton LNG. Looking from the economic view, MGO would not be attractive for shippers at that time.

On the other part, the infrastructure for LNG bunkering in Europe was not at a high level. Only in some Ports, Rotterdam and Hamburg, could LNG be bunkered and this did not give the market a reliable signal to use LNG as marine fuel. This was mainly caused by the lacking development of standards and legislation needed for the use of LNG as marine fuel. Another important aspect was the perspective people had in Western Europe about LNG. The lack of communication from the market and government towards the residents leaded to a misplaced fear for LNG. Another aspect which caused the lacking infrastructure was the fact that gas could be imported cheaper through pipelines from Russia. The in calculated gas supply from Russia was above the expectations. Europe imported nearly 400 bcm/year of gas in 2015 and LNG was only 4 % percent of this amount. Imported volumes stayed below the expected numbers and this caused an increase in LNG prices at the shipping markets. End of 2018 the prices increased to nearly €900 ton LNG.

At the beginning of the emission regulation in 2015, companies adapted the engines and used MGO to fulfill the restricted NO\textsubscript{x} and sulphur regulation. Investments to use LNG were high and the infrastructure was not significantly trustable for shipping companies. The lobby in the market for LNG was high, but the international developments of production and volumes in Europe were not enough to keep the LNG price competitive with other marine fuels. The price for HFO was stable hence no significant major events happened which could influence the oil prices. The prices fluctuated between € 400 to € 600 ton HFO between 2012 and 2015. Compared to MGO (1000 per ton) and LNG (900 per ton) HFO became attractive for the shippers. Beside that new technological developments could be noticed for scrubber technology. Wartsila was one of the key companies which had developed advanced technology to keep the sulphur and NO\textsubscript{x} levels according to the requirements in the EU. New methodologies were gradually developed in the supply industry and this provided shippers an alternative solution for the use of expensive MGO. Also in the beginning of 2020 new straightened for NO\textsubscript{x} and sulphur were accepted internationally which required additional scrubber systems for engines using MGO as alternative fuel.

2020-2030: The shipping companies move up to use HFO with scrubbers as marine fuel

LNG as marine fuel didn’t provide the expected price competitiveness as were assumed in the beginning of 2010. The price developments were negative and also bunkering facilities for ships were not at a high level realized. The EU government only set rules of the game for the shippers, but didn’t support them totally. The Dutch government provided financial supporting rules which helped the shippers investing in new clean technology. However these incentives were not enough for shippers to use LNG as fuel for their ships. The Dutch fleet had a new fleet so retrofitting would be the cheapest solutions to fulfill the new requirements. The costs for a new tank and engine to use LNG were not payable during the hard economic period at that time. Higher investments cost compared to scrubbers and the unreliable bunkering infrastructure made the shippers to try the scrubber technology.
Scrubber technology was not a state of the art technology at that period, but the shipping market had not many experiences. By then methods were developed to deal with the waste produced by the scrubbers. The main reason to use HFO was the fact it was much cheaper than LNG and MGO. New arrangements were made between engine companies and shippers. Test cases were developed to see how the waste could be handled in an environmentally good way. The Dutch government preferred the use of LNG because it doesn’t produced the waste scrubbers do and in their perspective moved to pollution from air to residual waste. The shipping companies saw the scrubber technology as the main profitable solution for their business.

When the lobby in 2012 was strong for LNG, guided by Norwegian companies like DNV, this was totally turned in the beginning of 2020. The high LNG price and the lacking development of infrastructure outplayed the hype created by the North European countries. New players entered the market and they provided good and cheap solutions to handle waste of scrubbers end therefore made them competitive in the market. The Ports in the Netherlands noticed these developments and decided also to provide new waste handling services. By the end of 2025 the 20 % the inland shippers in the Netherlands used HFO as marine fuel. At that time only 10 % used LNG and the main shippers sailed on MGO. In Norway the expected 30 % of the shippers which would use LNG was not achieved in 2020. Also the Dutch shippers were not attracted to LNG. Only 10 % of the inland shippers used LNG at the beginning of 2025 and only 15 % had announced to buy new vessels on LNG.

Internationally it was hard to realize LNG bunkering facilities out of Europe. This made the shippers also prefer HFO which was available all over the world. The dual fuel engines which ware produced to sail on oil as well as LNG was not successful as expected. These engines caused knocking effects which damaged the engines of the vessels.
5.4 Reflection on Scenarios

Three different scenarios have been written, based on the knowledge gained from the analyses conducted in this research. The data from market players have given new insights and served as information to validate and complement the knowledge available in the current literature. Many other different scenarios can be developed, because on each used factor like LNG price or investments cost can be varied in the different scenarios. For example: high investments cost for LNG installation can be the case in scenario 1, but also the government could take financial steps to stimulate the market. Here decisions are made based on the developments in the market, the analysis conducted and the expectations of experts.

These scenarios will provide the basics to test different strategies of actors in the shipping market. In the following chapter possible strategies of market players will be given and the possible effects in the future will be tested using the scenarios. Thereby a solid and robust advice will be given to market players which now are in a ‘wait and see’ position.
6  STRATEGIES FOR ACTORS IN THE LNG SYSTEM

6.1  SCOPE OF THE ANALYSIS
This chapter will give the end product of this research namely setting up robust strategies for important actors in the LNG system. This must not be seen as an extensive strategic study conducted to advice the market players in the system, but as simple suggestions how they could adapt their businesses to fit to possible future scenarios. In the literature many approaches exist on how cooperation could build up their future strategy, like the industrial organizational approach or the sociological approach. Within the approaches different levels of strategies exist like; cooperative strategy, functional strategies and operational strategies. To give extensive strategic recommendations on all the actors in the LNG system, these strategies must be able to contain detailed qualitative and quantitative studies on each of the mentioned levels within the strategic hierarchy. Because of the limited scope of this research, this cannot be realized. The core of this research was to give better insights in the working of the LNG system and to make clear how this system could evolve in the future. Based on the socio technical scenarios possible policies and strategies of actors in the system can be ‘tested’. The used method falls within the modern sociological approach of developing new strategies.

In this research we have used the TIP framework to analyze the current LNG system. The technical and institutional mechanism in the system has been analyzed in the chapters before. The process part of the analysis will be used to develop the strategies for the important actors in the system. Within the TIP framework the main idea is that the institutional and technical design cannot be conducted by one designer behind a desk, because of the multi-actor setting and the complexity of the system. Koppenjan en Groenewegen concludes in his article:

“The doctrine of process design assumes that designs are created in interactive processes between stakeholders. This can be an unguided, spontaneous process. However, process design is focused on improving that process by conscious efforts to structure it more adequately.”

In this research no designing is conducted based on each of the three levels of the TIP framework. However on the process level possible designs will be mentioned in this chapter, because the LNG system consists of many actors who act in a very complex environment. This analysis will help to shape the strategies for actors which finally can be tested in the developed scenarios in chapter 5. The question now rises: based on which criteria can these strategies be tested and compared to each other? Because each market player has his own interest and values, they will make decisions about their future strategies based on different criteria. To give an example: the shipping companies will give more value on the cost of investments than a bunker operator. Also the government will give more value to emission reductions than other private actors in the market. An overall list of criteria which can be applied for the whole market is not sufficient and will therefore not be conducted. Though the analysis used in 4.2.3 provides insight to set up criteria separately for each actor.

6.2  POSSIBLE STRATEGIES FOR ACTORS
In this research a detailed description of important actors concerning institutions and their role in the LNG system has been given. For each of these actors possible future actions, which they could conduct, will be given and tested in the scenarios presented in chapter 5. Shipping companies, Port of Rotterdam, the Dutch government, bunkering operators and engine producers will be the main actors where possible strategies for the future will be presented. It must be noticed that no detailed figures can be shown like: ‘the Dutch government has to create a funding budget of €800 million for the shipping industry. ‘No detailed quantitative strategies can be given due the scope and the conducted analyses in this research. These possible strategies will be set up partly from the suggestions which could be identified in literature, but also from the knowledge gained from the interviewees. Also own ideas will be incorporated. These possible strategies will be presented at the beginning of the sections in this chapter. Then these strategies will be ‘tested’ in the scenarios and finally
suggestions will be given to important market players in the LNG system (Because of limited time, only strategies of the crucial actors will be analyzed)

6.2.1 THE DUTCH GOVERNMENT

Possible strategies which the government can conduct in the future:

- Financial incentives in market
- Invest in institutional framework for LNG use in shipping industry (legislation, standards for bunkering)

In Norway the authorities have introduced a NO\textsubscript{x} fund which stimulates the shipping companies to fulfill the emission requirements. Here the government acts as an intermediate and tries to influence the ‘rules of the game’. Compared to the Dutch government it can be said that the policymakers in Norway are heavily involved in LNG projects. These two cannot be compared one to one because they differ on many factors like the amount of gas reserves, gas production, the way of distributing the gas and the perceptions people have regarding LNG. Norway has a more proven gas reserves than the Netherlands, 2039 billion cm compared to 1,387 billion cm (CIA, 2012). Besides the reserves, Norway liquefies gas into LNG which makes the transport possible in Norway itself. Because Norway has a landscape not prone to construct pipelines, LNG provides an alternative transportation solution. Nowadays it has become interesting to also export gas in the form of LNG. In the Netherlands the situation is in some way different. The Dutch government uses gas namely from the Slochteren gas field in Groningen and transport it by a solid national pipeline grid.

Another remarkable aspect which can be noticed is the fact that people in Norway are used to the applications of LNG and have a different perception towards this energy source. In the Netherlands it’s more freighted because LNG is seen as LPG. These types of factors make the situation not comparable and it can be understood that the Dutch government have an inactive position in the LNG system. It will be interesting to analyze how the government can serve the market and which policy they could conduct in the future.

From the interviewees it has been noticed that the Dutch government isn’t visible in the market regarding the support to use LNG and there is a lack in efforts to provide the market with clear legislation and standards. Another mentioned point is that in the market no financial incentives exists for market players to invest using LNG or providing services for LNG for example. The Dutch government is a powerful actor who can change the rules of the system and can play a significant role in which alternative fuel will be successful in the future. Though must not be forgotten that intervention of the government can disturb the competitiveness in the market. From this point of view several future actions for the Dutch government can be analyzed. Taken the opinions of interviewees into consideration, two possible actions can easily be conducted by the Dutch government.

Firstly the government can make the development regarding the legislation more clear for the Dutch shipping companies, but here it will be constrained by the European Union which makes the global decisions regarding legislation. Now there is an uncertainty about whether the regulation will be implemented outside the SECA region or not and will the rules regarding sulphur and NO\textsubscript{x} emission be internationally implemented. Another option will be to financially support market players who invest in environmental friendly marine fuel solutions. Because the economic situation in Europe is falling back and many European countries could face a new economic crisis like Portugal, Spain and Italy, the Dutch government must also cut their expenses in the future. Both actions will cost the government money and time, so it can be wise to have one strategic focus for the future. To see which actions and strategies will be robust for the actor, the described scenarios in chapter 5 will be used.

One of the options for the Dutch government would be to invest in a stronger institutional framework (legislation and standards for LNG usage) for the shipping industry. Looking at scenario 1, it can be noticed that this will help the system to fasten the introduction of LNG in the shipping industry. Besides this, market players
will have certainties and could adapt their businesses to the rules in the market. If this is not done by the government, LNG as marine fuel will not play a significant role in the Dutch shipping industry. This can also be noticed in scenario: the market is building up speed when legislation came into power and the market gets trusted with LNG. Also the same can be noticed in the last scenario: the shipping industry is not fully developed and prepared to use LNG so scrubber technology gets in advance. In all the scenarios it can be noticed that legislation and standards would help or fasten the introduction of LNG as marine fuel in the industry. However, is this the aim of the government? Is it important that the share of LNG vessels increases in the Dutch waters? The main idea is to reduce the sulphur and NOx emissions. When the government only focuses on LNG, will this not disturb the competitiveness in the market where market players also invest in other emission reducing technology?

Secondly the government could made financial subsidies in the market. Policies based on financial incentives could have a fairer and equal effect in the market. In all the scenarios, new marine fuels will lead to higher prices for the shipping companies. The rules of the game will change in Europe and this is a certainty in the future. Taking the mechanism of the shipping industry into account, it can be said that financial aspect are very important. If the government could financially support all the technologies which will help to reduce the emission, a fair game will be introduced in the market. This is not an eye opener, because the same policy is carried out in Norway by the NOx fund. A financial policy will probably cost the government more, but it will give more incentives for market players and will help to take the uncertainties of the future into account. Only focusing on LNG legislation and standards would not be the most robust alternative, because also for the Dutch government it is important that the emission reduction goals will be feasible in 2015. There remains the risk that LNG will not be successful at all (scenario 3), and focusing on one marine fuel will not be a solid policy for the future.

6.2.2 PORTS
Possible strategies which the Ports can conduct in the future:

- Investing at Ports
- Forming alliances with market players

The Ports are in the supply part of the logistical chain and they will mainly provide the infrastructure for LNG bunkering in the future. The Port of Rotterdam and Amsterdam have an important strategic position in the Dutch waterways. They also follow the developments regarding LNG as fuel and are looking how they can provide the market with new additional services. However there are risks involved for them regarding the provide LNG as marine fuel. First of all the safety risks with LNG are uncertain in the Netherlands. One test bunkering activity has been conducted by A.Nobel en Zn in Zwijndrecht. The involved actors, like the municipality and provincial government, were surprised about the handling of LNG. The common perception of not involved actors, like residents and NGO’s, is that using LNG is a dangerous activity. The questions remain where the best location will be for LNG storage for the tanks and how bunkering can conducted on a save way. Another important uncertainty will be the volumes of LNG demand in the Dutch shipping market.

The risks are based on the investment which could be earned back from the LNG activities they will conduct in the future. It can be risky if LNG will not be used as marine fuel in the future. Looking at scenario 1 and 2, LNG will probably have a solid share in the shipping industry on the middle- long term. Also the developments sketch in Western-Europe shows that LNG will be attractive for inland and short sea shipping. Only if scenario 3 occurs the Ports will not have positive results regarding their LNG investments. However larger Ports must be distinguished from the smaller Ports hence these can follow different strategies. A larger Port can take more risks regarding financial steps and can take greater risks. Also smaller Ports can decide to invest in LNG bunkering because they see can LNG as an opportunity to strengthen their competitive position in the market.
It’s obvious that the financial factors like CAPEX, OPEX and ROI will be decisive for the ports. Looking at the three scenarios, it is notable that LNG will play a significant role in the Dutch shipping industry. For that reason the Ports will not undergo high financial risks. However the question remains how big the investments must be and when investment must be conducted. In scenario 1 and 2 it is expected that the demand after 2016 will grow and LNG will stabilize in the shipping industry. For example: if the Port of Rotterdam make large investments within 2 years for bunkering of LNG to vessels, regarding the scenarios the time needed to earn the investments back will be longer due the lack of demand from the shipping companies in the near future. On the short term it would not be interesting for the Port.

Besides focusing on investments of the Ports, other strategies can also be interesting, like forming alliances with other market players. Short term or long term cooperation can also be a solution to calculate future uncertainties in their business activities. During an interview with interviewee of the umbrella organization Ports, he proposed a ‘total logistic approach’ to catch extra costs for shippers regarding the use of LNG. Therefore cooperation between the firms is needed. From this point of view, cooperation with bunkering operators could be an interesting option for the Ports. This type of cooperation can already be noticed, for example: the PoR and Argos are looking to the safety issues when LNG is handled (Schuttevaer, 2011). For now similar projects seem to not have the desired effects for the involved actors. Currently many projects are based on research and cost estimation, but no practical test cases are conducted. Koedoe, Wartsila, Reederei Deymann and Buijks Duwaart BV have announced the ‘Project Binnenschip 2020’ to test three new concepts mainly focusing on dual fuel engines. Here Dutch-German cooperation is valid and they expect a real monitoring period of 3 years after the conceptualization of ideas has been realized. The question here is whether the Ports in the Netherlands undergo risks regarding the changing regulation in 2015. The Gasunie and Vopak recently realized an LNG import terminal, called the Gate terminal, with a storage capacity of 540.000 m$^3$and send out capacity of 12 bcm a year. The LNG is imported from Nigeria, Norway and Algeria. The Port doesn’t have to think about large investments to provide new additional services to realize the infrastructure for LNG bunkering. Also the Gasunie and Vopak have announced to deliver LNG before 2015 to vessels by making two new jetties next to the Gate terminal. In this perspective, no high risks are involved for the Port of Rotterdam. Higher demand in the future can easily be handled by expanding the needed capacity to deliver LNG from supplier to customers.

Obviously the Port of Rotterdam wants to keep their reputation worldwide and stay competitive in the global market. In that perspective the Port must be aware of delivering new services and keep up with new upcoming innovative ideas. In that perspective the Port will not have to choose between LNG or HFO, but will have to provide the infrastructure for both of the marine fuels. The attractiveness of the Port must be continued and in that perspective, green incentives from the Port itself can contribute to their reputation. Thereby you could think about lowering the Port tax for green operating vessels, or other incentives which could please current customers.

6.2.3 SHIPPING COMPANIES
Possible strategies which the shipping companies can conduct in the future:

- **Wait and see approach**
- **Process approach: participate in test projects with market players. Forming alliances and cooperations**

The shipping companies are part of the demand side of the LNG chain and they will decide which type of engine they will use to satisfy the new emission demands in 2015. They are crucial in the sense that they will determine the demand for LNG in the shipping industry and how the demand will grow or decline in the future. Their strategy will be important, because an unwise decision now will have great effects in the future. If they decide to buy new LNG vessels or retrofit their ships to use LNG, significant investments will be needed. When the future doesn’t bring the calculated advantages of LNG as marine fuel, like low fuel and operating costs,
then their followed strategy will be unsuccessful. Also when the required infrastructure for LNG will not be available in the Netherlands and all over Europe, they will face operating problems. Also this will be the case when they now invest in scrubber technology, but the oil prices increase in the future which will lead to higher operating costs. The decision made by the shipping owners cannot be made undone, so they carry the most risks compared to other actors.

Taking the scenarios into account, it can be considered that MGO will be the next steps for the shipping companies in the future. The uncertainties regarding the infrastructure and price of LNG, the untested HFO scrubber technology and waste handling makes it risky for shippers to totally adapt their vessels in the short term. From 2020 it is expected that shippers will follow different strategies. Scenarios 1 and 2 are show that LNG will have a market share between 20 % and 30 % and will grow further after 2030. Scenario 1 shows a pessimistic penetration of LNG in the shipping market. Scenario 3 shows a more successful penetration of scrubber technology and an ignorable presence of LNG as marine fuel.

Because shipping companies operate in different sub markets like, inland shipping, short sea shipping, ferries, and international waterways, it will be hard to advise each shipping company active in different markets. For each market segment a new study can be conducted. The shipping companies have their own operating characteristics which will decide whether LNG will be attractive or HFO or MGO. Also it will hard to say whether it would be wise for them to retrofit their vessels or purchase new ones. These advices cannot be made based on the conducted analyses.

Though detailed analyses for the shipping companies are missing, a couple of advices could be given. From the experiences during the visited conferences and interviews with involved actors in the system, it was noticed that the shipping companies are not visible in the market. During the conferences different market players were involved, except the shipping companies. The interviewees mentioned also the inactive positioning of the shippers during this period of time. It can be understood that it will be hard for the shippers to satisfy the new emission rules in the coming years during the hard economic periods, but the coming years will also determine which company will be innovative enough to survive in a game were the rules are tough and tightened. Also the shipping companies try to delay the new emission rules in 2015 and want more time to overcome the coming years to see how the market will develop in the near future. They are for now unfamiliar with LNG and scrubber technology leading to an unreliable market situation at this moment.

Keeping this attitude in the market will not help them to get more trusted with the alternative fuel options. Suggestion is to focus on a process approach of the system, in which openness is required towards the market and preparedness to cooperate with other market players. One example can be given: Reederei, Koedood and Wartsila are now cooperating to make feasible what the cost will be of different alternative fuels, by setting up test cases. Similar projects can be set up by other shipping companies to get more trusted with technology. Also cooperation with bunkering operators and government could be set up to get more insights in the required standards for bunkering infrastructure and possibility of financial support from the government. Cooperations and alliances could be formed to test different options and to get more insights in required standards for safety and ship design. To use the ferry operators as example:

Ferries have fixed operating routes in the North Sea. Thereby infrastructure for bunkering of LNG could be realized which can be used by these companies. This is often indicated by interviewees and noticed in the literature. To test this and to look whether the use of LNG is feasible and attractive for ferry operators, cooperation with bunkering operators can be formed. Because many parties are in a wait and see position and don’t have the courage to invest in new innovative ideas, alliance or cooperation could take away these uncertainties.

Anthony Veder is one of the Dutch firms who already have ordered a LNG vessel which will transport LNG to potential new customers. They are one of the few actors who are investing now and believing in the high
potential of LNG in the European market. For now they will serve customers who will demand low volumes of LNG, who are not capable of importing on his own. Their market approach is not to wait now, but to invest now taking the global trends in Europe into account. These risks can be taken by such a firm, who are capable of financing new investments. Contrarily, other shipping companies are smaller and do not have the financial power to follow the same strategy.

6.2.4 ENGINE PRODUCERS

Possible strategies which the engine producers can conduct in the future:

- Invest in gas engines and additional services
- Invest in dual fuels and additional services
- Invest in scrubber technology and additional services

The engine producers are delivering the required technology for the vessels to use different marine fuels in the future. Different important companies are involved and each follows their own strategy. These strategies can be derived by the products they are delivering right now. These companies have already chosen which direction they will follow and how they will position in the future. This section will present the strategies of different companies in the system.

Wartsila is one of the companies who have developed dual fuel engines. These engines are capable of using gas as well as diesel. These engines take away the uncertainty of LNG bunkering in areas where infrastructure is not available. Wartsila in this case has chosen to deliver these engines because they probably expect that LNG as marine fuel will not have a great share within the shipping market. As we look at the scenarios, we could see that these engines could be successful in scenario 1 and 2. Here the expectations are that LNG will have a market share between 20 -30 % in the Netherlands. The company can in those cases supply engines which could fulfill the demand in the shipping market. Wartsila bets not only on LNG, but makes it for their customers possible to also use current diesel and gasoil fuels. Besides dual fuel engines, Wartsila also have developed scrubber technology to use HFO. Hereby it is remarkable that Wartsila doesn’t have focused only one marine fuel option, but on all. It can be concluded that Wartsilas strategy is robust in the three different described scenarios. They have products which could be used in the three different described scenarios. If HFO will be the main used marine fuel in the future, they will have engines which could make that possible. If LNG for example will be attractive in the future, they will be able to deliver dual fuel engines which can use LNG as fuel.

Rolls Royce contrarily can deliver only lean burn engines which uses LNG as marine fuel. They have no dual fuel engines and also no developed scrubber technology. Compared to Wartsila, they have chosen to focus on LNG. Looking at the scenarios, they bet on scenario 1 or2 will occur. In that case they could meet the demand in the market. But when scenario 3 occurs and HFO will be the attractive solution for the emission regulation, then Rolls Royce will not be able to compete with other engine producers. Here it can be concluded that they have a less robust strategy compared to Wartsila.

Other engines producers like Mitsubishi and Caterpillar has also products which could satisfy the new demands in the future (Hart, 2009). Mitsubishi has gas engines which operators on the famous Pioneer Knutsen in Norway, build by Bijlsma. Contrary, Caterpillar has experience with dual fuel engines. The engine companies have each their own experiences and products in the market and they try to sell these on the market. At conferences it could be noticed that namely Rolls Royce and Wartsila are active and try to influence other market players in the industry. Mostly in all current cooperation and projects set up to develop LNG as marine fuel, these companies are involved. In that perspective you could say that they are highly involved but another aspect must here be noticed. From the conducted interviews, it was mentioned that the services of these companies to adapt vessels are very high at the moment. Also it is noticed that these companies are not transparent enough about their products.
6.2.5 **BUNKERING OPERATORS**

Possible strategies which the bunkering operators can conduct in the future:

- *Cooperation with shipping companies*
- *Alliances with knowledge institutions*

The bunkering operators will provide the infrastructure which will make it possible to use LNG as fuel in the shipping industry. They are another important actor with crucial power in the LNG system. They cannot have a profitable business without shipping companies using LNG and vice versa. The operators will deal with two important business questions: ‘where do we place LNG stations and when?’

From the conducted interviews and literature studies several potential shipping markets could be identified. In scenario 1 and 2 the inland shipping and short sea shipping will have a potential market to use LNG as marine fuel. In that perspective it could be said that along the important inland waterways like the Rhine new LNG bunkering facilities will have business potential in the future. However the operational profits will possibly be after 2020 regarding scenario 1 and 2. It is expected that the demand for LNG before 2020 will be low, so on the short term a profitable business is not expected for the bunkering operators like Argos and Nobel. They heavily depend on the demand for LNG in the market. Based on scenario 3 LNG bunkering facilities will not be profitable at all because HFO will be the attractive fuel in the shipping industry.

The risks remains for bunkering operators and it will be hard for them to predict the LNG demand in the near future. Also there is uncertainty about in which shipping markets the demand for LNG will be grow in the near future. The ferries and inland shipping has an expected good potential regarding the input from the interviewees, but no quantitative data can be given about volumes and prices. To reduce these uncertainties and to explore the market potential, A Nobel and Zn have realized the first LNG bunkering station in the Netherlands. Deen shipping is the first shipping companies which will use LNG for their business activities. Here it could be noticed that an operator and user of LNG are cooperating to have a basis in a new business case. In that sense the operator secure that he could deliver LNG to the customer. Other way the shipping companies secures he could bunker LNG during his operations.

This will be a good example how the market can start to develop in the coming years and other parties can be contacted with the opportunities of LNG. Possibly other shipping companies will see the possibilities of LNG and thereby think about cooperation with A. Nobel. or other new operators could start up with a same construction with other shipping companies. This is an opportunity but for now this seems to be hard to realize in reality.

Looking at the scenarios, LNG will have potential at the middle long term when more security is regarding legislation, standards and LNG prices. For now the operators are in a wait and see position also because no standards and legislation is valid for bunkering of LNG. Therefore this barrier must be tackled even before they could think about delivering LNG in the market. Also here it could be noticed that market parties try to tackle this hurdle: Argos, the Port of Rotterdam and TNO are working on the LESAS project which must make the risks clear when LNG is bunkered at the Ports and which locations have a good potential to realize LNG bunkering stations. For now these cooperation has not delivered the market enough confidence to invest independently in LNG bunkering. To give an example: Argos announced to have bunkering ships round 2016, one year after the new EU regulation will be active. This also show that they are waiting rather they take the risks now. However it must be mentioned that Argos believes in innovation and wants to invest in LNG services in the coming years. Their market approach in which they search new cooperation and dialogue with other market players can serve as an example.
The strategy operators are following can be understood, because the market doesn’t give positive signals that LNG will have a great potential in the short term. A suggestion will be that the cooperation between operators and shipping companies will help to get more confidence and trusted with technology. Also uncertainties like the unavailability of infrastructure and LNG demand in the market could be taken away. On the other hand knowledge institutions and engineering companies are also involved which could have added value in developing new business opportunities. Parties like Deltalinxs, TNO and the TU Delft could act like an intermediate between private market players and bring experience and knowledge together.

6.3 CONCLUDING REMARKS

Most of the interviewees mentioned that test cases are missing and market players could not calculate which effects their investments will have for the future. It will be hard to finance these test cases and it will be hard develop standards and new ship designs on your own. In that perspective cooperation with other market players will help to overcome these barriers. What also has been noticed is that the government has an inactive role in the market. A suggestion could be to get the government more involved in projects and to give them also the urge of the emission rules from the EU. From own experiences during this research, it could be noticed that an facilitator or broker in the market is missing. Everyone is looking for opportunities and each announce that they see new opportunities regarding LNG, but no real actions are carried out. The lobby for LNG is strong and every month there are several conferences organized all over Europe.

The new sulphur and NOx rules will be introduced in 2015, but the ongoing projects in the market will not be finished before that time. It’s is not real to expect that vessels will use LNG on short term in the Netherlands. Lacking standards and legislation are the most mentioned barriers in the market, but how logical is this when LNG is used as marine fuel in Norway for years? And also, how will the EU reinforce the shipping companies to satisfy the emission regulations? This is not mentioned in the literature and also nothing is told at the conferences (Flevum conference and IIR conference). How strict will the rules be maintained in the industry?

Though the government is inactive and this is underlined by interviewees, the inactive attitude towards LNG could be imputed on private market players. They want to see what the use of new innovation will cost and what if it will be profitable for their businesses. Because the economy will face difficulties in the future in Europe, the cost for new investments are very important for market players. In that sense more cooperation and alliances can be set up to make the economic effects and opportunities of LNG clear. Legislation and standards are important but are not hard to develop compared to business models. Here intermediate or broker parties like engineering companies, Deltalinxs and TNO could play a significant role. By their positioning and independences in the market they could bring for example shipping companies and operators together and could work on profitabale business models.
7 CONCLUSION AND RECOMMENDATIONS

The introduction of LNG in the shipping market will occur in a highly complex system. The presence of many market players and the uncertainties regarding important factors exposed the high complexity of the system. The attractiveness of LNG as marine fuel compared to other fuels like, HFO and MGO, are driven by the availability of bunkering infrastructure, performances of the engines, and the costs of new LNG vessels. The cost related to engines and infrastructure is clear for now, but mainly the price of LNG in the future is uncertain. This make the shipping companies settle and position them passive in the market for now, because they could not make solid comparisons with other marine fuels. Besides these technical and price barriers, also other barriers influence the attractiveness of LNG. Undeveloped standards for bunkering infrastructure, undeveloped and uncertain legislation regarding the use of LNG as marine fuel in the Netherlands make the market players delay possible investments in LNG related businesses.

The main critical actors in the shipping market are the shipping companies, LNG bunkering operators, and the Ports. Firstly the shipping companies will be the most important actor in the system, because they have the decision power to choose for LNG or the other marine fuels. These companies will be the ones who will pay for the consequences of the new regulations in the ECA region. The other market players will provide the attractiveness of LNG for the shipping companies. The Ports and bunkering operators will bring the LNG to these shipping companies, but they face problems regarding the uncertainties of safety requirements. Also undeveloped standards cause delays in realizing LNG bunkering facilities in the Netherlands. For now many opinions and conducted studies are introducing LNG as a marine fuel which is cheaper compared to HFO and MGO. Also knowledge institutes, bunkering operators believe that LNG will be the future marine fuel. Believing or not, these companies can make profits and add additional services to their portfolio, but will not undergo the same risks as the shipping companies. Many market players therefore complain about that the government has an inactive positioning in the market and doesn’t accelerating the developments of standards and legislation. Many refer in this case to the Norwegian government. The market is processing slowly and the uncertainties are not becoming certain for the involved actors. For now the shipping companies are in a wait and see position, where the other market players try to break through the barriers.

The three different scenarios indicated that on the short term, MGO will be the attractive marine fuel for the shipping companies. On the middle long term, LNG will compete with scrubber technology in the shipping market. The mainstream global scenarios which can occur:

- Introduction of LNG (scenario 1): One scenario that could occur is the slow introduction of LNG, but on the middle long term fast development of LNG as marine fuel in the shipping industry. After 2020, LNG could win more market share when the LNG price stays attractive and the uncertainty regarding missing institutions and bunkering facilities is taking away.
- Hybridization (scenario 2): Another scenario which can occur is the hybridization in the market. MGO will be on the short term the marine fuel which will provide the shipping companies the alternative fuel to satisfy the emission rules. After 2020, LNG can become also attractive when the uncertainties like standards and legislation and missing infrastructure is taking away.
- Scrubber technology (scenario 3): A scenario which also can occur is that scrubber technology will be more attractive than LNG after 2020, because the low HFO prices and the secure current bunkering facilities. The missing standards, legislation and infrastructure for LNG will lead that market players will use scrubber technology to fulfill the emission rules.

It’s obvious that LNG as marine fuel will face startup problems in the beginning phase. The current ongoing projects to test LNG as marine fuel will be finished after the new regulations will be introduced in 2015. The uncertainty remains how the LNG price will be determined in the future. Will it be coupled to the oil price or will LNG be sold on the spot market? If the LNG price drops and the EU will have a forcing power to maintain
the emission regulation in the future, then it is expected that the introduction of LNG as marine fuel will be hastened. For now many shipping companies will use MGO/MDO to fulfill the emission regulations after 2015, despite the high fuel price. Beside the LNG price, also the unavailability of bunkering stations all over Europe and internationally leads to the unattractiveness of LNG as marine fuel. It is not expected that these facilities will be realized at many ports in Europe in the short term. Also the question remains whether internationally LNG bunkering at Port will be available. Another question which rises is the uncertainty about how strict the EU and member states will reinforce shipping companies to satisfy the emission rules? The lack of clarity also exist whether emission regulations outside Europe will be introduced and uncertain LNG price in the future will lead shipping companies to focus MGO at the short term. On the middle long term LNG can become attractive when the bunkering is available at many Ports in Europe and when the LNG price becomes more certain in the future. The high MGO/MDO price will, on the middle long term, lead shipping companies to consider using LNG or scrubber technology. The lower fuel operating costs of LNG use compared to scrubber technology can lead shipping companies to focus more on LNG. Taking these current developments into account, it is highly possible that scenario hybridizations will occur. But it would not be wise for market players to only bet on one possible scenario. Therefore robust market strategies can be given to market players by considering the three different scenarios.

The market players are in a highly potential field to make investments, but some have higher risks than the others. The main question of the research was to show which perspectives LNG provide for the shipping industry in the Netherlands. The following suggestions for the important market players can be given:

**Shipping companies:** Taking the scenarios into account, it can be considered that MGO will be the next steps for the shipping companies in the future. The uncertainties regarding the infrastructure and price of LNG, the untested HFO scrubber technology and waste handling makes it risky for shipping companies to totally adapt their vessels in the short term. From 2020 it is expected that shipping companies will follow different strategies. Scenarios 1 and 2 are show that LNG will have a market share between 20 % and 30 % and will grow further after 2030. Scenario 1 shows a pessimistic penetration of LNG in the shipping market. Scenario 3 shows a more successful penetration of scrubber technology and an ignorable presence of LNG as marine fuel. For now it has been mentioned that shipping companies are invisible in the market and don’t have an active attitude to fulfill the new emission regulations in 2016. Keeping this attitude in the market will not help them to get more trusted with the alternative fuel options.

Suggestion is to focus on a process approach of the system, in which openness is required towards the market and preparedness to cooperate with other market players. One example can be given: Reederei, Koedood and Wartsilä are now cooperating to make feasible what the cost will be of different alternative fuels, by setting up test cases. Similar projects can be set up by other shipping companies to get more trusted with technology. Also cooperation with bunkering operators and government could be set up to get more insights in the required standards for bunkering infrastructure and possibility of financial support from the government. Cooperations and alliances could be formed to test different options and to get more insights in required standards for safety and ship design.

**Ports:** The risks are based on the investment which could be earned back from the LNG activities they will conduct in the future. It can be risky if LNG will not be used as marine fuel in the future. Looking at scenario 1 and 2, LNG will probably have a solid share in the shipping industry on the middle- long term. Also the developments sketch in Western-Europe shows that LNG will be attractive for inland and short sea shipping. Only if scenario 3 occurs the Ports will not have positive results regarding their LNG investments. However larger Ports must be distinguished from the smaller Ports hence these can follow different strategies. A larger Port can take more risks regarding financial steps and can take greater risks. Also smaller Ports can decide to invest in LNG bunkering because they see can LNG as an opportunity to strengthen their competitive position in the market. It’s obvious that the financial factors like CAPEX, OPEX and ROI will be decisive for the ports.
Looking at the three scenarios, it is notable that LNG will play a significant role in the Dutch shipping industry. For that reason the Ports will not undergo high financial risks. However the question remains how big the investments must be and when investment must be conducted. In scenario 1 and 2 it is expected that the demand after 2016 will grow and LNG will stabilize in the shipping industry.

The Ports want to keep their reputation worldwide and stay competitive in the global market. In that perspective the Ports must be aware of delivering new services and keep up with new upcoming innovative ideas. In that perspective the Ports will not have to choose between LNG or HFO, but will have to provide the infrastructure for both of the marine fuels. The attractiveness of the Port must be continued and in that perspective, green incentives from the Port itself can contribute to their reputation. The current standards and legislation for bunkering facilities are undeveloped. The Ports can cooperate with bunkering operators and shipping companies to accelerate these developments in the near future.

**Bunkering operators:** In scenario 1 and 2 the inland shipping and short sea shipping will have a potential market to use LNG as marine fuel. In that perspective it could be said that along the important inland waterways like the Rhine new LNG bunkering facilities will have business potential in the future. However the operational profits will possibly be after 2020 regarding scenario 1 and 2. It is expected that the demand for LNG before 2020 will be low, so on the short term a profitable business is not expected for the bunkering operators like Argos and Nobel. They heavily depend on the demand for LNG in the market. Based on scenario 3 LNG bunkering facilities will not be profitable at all because HFO will be the attractive fuel in the shipping industry. A suggestion will be that the cooperation between operators and shipping companies will help to get more confidence and trusted with technology. Also uncertainties like the unavailability of infrastructure and LNG demand in the market could be taken away. On the other hand knowledge institutions and engineering companies are also involved which could have added value in developing new business opportunities. Parties like Deltalinqs, TNO and the TU Delft could act like an intermediate between private market players and bring experience and knowledge together. At the current time, the uncertainties in the market make the actors to passive. They doesn’t have the trust to invest in LNG businesses and don’t want to take the risk by themselves. The added value of facilitator could be to trigger the market players to work together. By cooperating the developments of new standards and legislation could accelerate and the risks could be divided.

**Dutch government:** One of the options for the Dutch government would be to invest in a stronger institutional framework (legislation and standards for LNG usage) for the shipping industry. Looking at scenario 1, it can be noticed that this will help the system to fasten the introduction of LNG in the shipping industry. Besides this, market players will have certainties and could adapt their businesses to the rules in the market. If this is not done by the government, LNG as marine fuel will not play a significant role in the Dutch shipping industry. This can also be noticed in scenario 2: the market is building up speed when legislation came into power and the market gets trusted with LNG. Also the same can be noticed in the last scenario: the shipping industry is not fully developed and prepared to use LNG so scrubber technology gets in advance. In all the scenarios it can be noticed that legislation and standards would help or accelerate the introduction of LNG as marine fuel in the industry. However, is this the aim of the government? Is it important that the share of LNG vessels increases in the Dutch waters? The main idea is to reduce the sulphur and NOx emissions. When the government only focuses on LNG, will this not disturb the competitiveness in the market where market players also invest in other emission reducing technology?

If the government could financially support all the technologies which will help to reduce the emission, a fair game will be introduced in the market. This is not an eye opener, because the same policy is carried out in Norway by the NOx fund. A financial policy will probably cost the government more, but it will give more incentives for market players and will help to take the uncertainties of the future into account. Only focusing on LNG legislation and standards would not be the most robust alternative, because also for the Dutch
government it is important that the emission reduction goals will be feasible in 2015. There remains the risk that LNG will not be successful at all, and focusing on one marine fuel will not be a solid policy for the future.

Suggestions which followed from this research are mainly based on cooperations of market players can conduct, rather than the focus on the further development of technology or legislation. The market players are inactive towards system innovations in the shipping industry. Mainly the shipping companies are in a wait and see position and because the other actors heavily depend on these companies, development regarding the use of LNG is a slow going process compared to developments in Norway for example. It must not be forgotten that the focus must not only be on LNG, because the goal is not to introduce LNG as marine fuel, but to fulfill to the emission regulations in 2015.

LNG as marine fuel provides high chances for market players to make new businesses in the future, but if all the parties in the LNG chain will have the same perception (high potential and believe in LNG). The literature and conferences present LNG as marine fuel as the next fuel for the shipping industry in the coming decade. But the real world has another opinion and is more skeptical about the potential of LNG in the short term.

Recommendations

Based on findings of this research several recommendations could be given to market players:

First of all the shipping companies must now participate more actively in the network of actors. This will help them to find solutions to satisfy the new emission rules in 2015. By cooperating and forming alliances with other market players, the innovation process will be accelerated. Also the financial risks which come along with new innovative system could be divided on the participating actors. This will finally lead to a process in which the uncertainties regarding LNG as marine fuel will be taken away. Better decisions could be made whether it would be wise to use LNG or scrubber technology in the future. What is observed now is that these companies are isolated in the market and fear the effects of these sulphur and NOx regulations on their businesses.

Secondly, to achieve these networks of alliances and cooperation in the market, some market players must take the responsibilities to pull and push other players in the market. Thereby important roles like, a broker or a facilitator, can be fulfilled by knowledge institutions and governmental bodies. Also engineering firms, like Royal Haskoning, can fulfill these roles in the market. At the current time, market players don’t trust new innovative ideas because the high risks which are involved. A bunkering facilitator can realize bunkering stations for LNG vessels, but if there is no demand in the market these investments will be useless. The market players therefore need each other to have profitable business. The facilitator could bring the demand and supply in the market together and trigger the cooperation between the firms. Market players, like shipping companies or bunkering operators could also fulfill these roles by themselves, but independent and objective actors like knowledge institutions will fit the role as facilitator better.
8 DISCUSSION

In this chapter decisions, assumptions and limitations made in this research will be discussed. In this research the mechanism of the system are divided into technical, institutional and process parts (TIP). These mechanisms are then used to build scenarios which served to test strategies of actors in the LNG system. Mapping system innovations has been conducted by familiar approaches in the past, like by van den Bosch (Bosch, Brezet, & Vergragt, 2005). He also conducted interviews to map important stakeholders in the system and obtained their goals and interest. In this research this approach has been extended by using scenario analysis of Geels to also take the uncertainties of the system into account.

8.1 REFLECTION AND LIMITATIONS OF USED METHODOLOGY

To build the scenarios the STSc method of Geels has been used. This approach provided a solid base to map system innovation within a complex system. The stakeholder analysis provided input for the landscape, regime and niche levels of the scenarios. The causal analysis provided the interaction between the different levels. The scenarios are in that perspective based on literature, interviews and own expectations. As mentioned in chapter 5 of this report, Geels had critics about the missing mapping tools he provided to map actors behavior at the regime levels of the scenarios. This research added a tool to map the behavior of actors in the regime level of the STSc. While using this method, the experiences made in this research showed that this method cannot deal with quantitative numbers and figures. Therefore assumption where made about the LNG price after 2020 and for example the additional investments for shipping companies after 2020. In the LNG system figures like oil price, LNG price, fuel costs are very important and uncertain for the future. The effects of for example LNG price increase in the future could be given, but not specific in numbers. How strong will a small LNG price increase influence for example the fuel operating cost of shipping companies? These insights are also important for the robustness of the scenarios. Therefore this methodology could be extended with a quantitative research approach.

System dynamics is a methodology which could provide solutions to deal with important quantitative figures in the scenarios. This is an approach to understand the behavior of complex systems over time (Sterman, 2001). The methodology of system dynamics is already used in this research to analyze the technical part of the LNG system qualitatively (causal diagram, Figure 12). By conducting system dynamics modeling, the structure of the LNG system and changes over time could be presented quantitatively. This approach will add value to the STSc methodology of Geels and will help to map the changes of uncertainties of the system in time. Finally this will give the actor/problem owner a tool to see quantitatively what the consequences of his action can be over time. Thereby a further research can be conducted taking this research as starting point and extending the STSc methodology with system dynamic modeling.

The STSc is a powerful method to map innovative transition in the current markets. It provides a hand tool to analyze the market from different perspectives, namely from a technology, social, institutional and economical perspective. Beside these perspective, it uses and interrelates small to global factors so the user doesn’t have to scope his problem field or market definition. It can be recommended to use this method for other system innovations, like the introduction of smart grids in the electricity sector or the introduction of electric vehicles in the Netherlands. This method could be used as a policy tool for decision makers working at governmental bodies or it could be used at companies to map their innovative ideas in new markets. While using the methodology of Geels, it has been noticed that the method provides a global framework to map transition in markets, but it doesn’t provide explicitly analyses tools to gather information. Also the methodology says what has to be analyzed in the market, but not how. During this research, stakeholder analysis and causal analysis has been used to complement the methodology of Geels. In that sense the methodology misses specific analyses tools to use the STSC, but on the other hand it provides the user the freedom to approach the transition with own ideas and analyses techniques.
Beside the STSc, the TIP approach has been used to analyze the LNG market from different perspectives. After the literature study had been conducted during this research, it was noticed that the LNG market mainly was mainly analyzed from an economic and environmental perspective. The TIP approach is used to design infrastructure and other systems in which different levels are taking into account, like the technology of system, the institutions of the system, and the process involved to come to the desired design. In this research this approach is not used to design, but to explore and analyze the LNG market. In that perspective this methodology has been applied with another purpose, but now, after applying this approach, it can be said that it also can be used as a analysis tool. The TIP approach compliments the incomplete method of Geels and provided a systematic tool to analyze the transition in the LNG market. It can be recommended to use the TIP approach to analyze mechanisms in other markets, but also in this approach has difficulties to deal with quantitative numbers. Because institutional and process analyses don’t dive into hard numbers and figures, it was difficult to complement this approach with quantitative analyses. But on the other hand, the technical part of the TIP approach provides enough room for extension towards quantitative analyses.

8.1.1 Use of methodology in another market

To give an example in which other market the TIP approach and STSc can be applied:

The use of electric vehicles in the Dutch cities: transition in the automobile market. The Ministry of Transportation in the Netherlands had announced to introduce new electric vehicles to reduce the PM emission of cars in the Dutch cities. Therefore it had started a program to attract market players to invest in the development of infrastructure where vehicles could charges the batteries. Also incentives where announced which would have to made the purchase of an electric vehicle more attractive (V&W, 2009) (PBL, 2009) (Passier & Driever, 2009).

Also in this market there is a similar situation: the chicken and egg problem. There are not enough infrastructures to charge electric vehicles, but also there are not enough electric vehicles to realize a solid infrastructure. Also here market players are waiting for each other en till now, not many electric vehicles could be seen at the cities of the Netherlands. The policy makers of the Dutch government could also use the STSc methodology to map the uncertainties in this market. Also in this case, many economies, environmental and statistical studies are conducted to see whether electric vehicles could compete with incumbent fuel engines. Many international studies are valid (Calef & Goble, 2007) (Ogden, 2004) (Lieven, Muhlmeier, Henkel, & Waller, 2010) (Kurani, Torrentine, & Sperling, 1996). All of these studies have in common that they approached the innovation in the market from the same angle: economy, environment and users demand.

The TIP approach provides a tool that adds a new perspective to analyze innovative systems towards transition in markets. For now it can be noticed that the Dutch policy didn’t have the expected effect. The TIP approach can give the policy makers a new tool to not only analyze the market from an economical or environmental perspective, but also take the social and institutional mechanism of the market into account. This is mainly missing in the mentioned studies which are conducted with similar transitions in market. By taking these mechanisms into account, robust strategies could be developed by policy makers to approach new innovation in markets.

In this research system innovation has been approached from the TIP framework. The experience made in this research showed the usefulness of this methodology and confirmed that it adds a new dimension in analyzing new innovative concepts in markets. It will be hard to conclude after one research that this approach must be used when analyzing or designing new system innovations in markets. However this TIP approach can be used in further researcher related with system innovations in markets and this could be elaborated more with other methodologies or tools. More experiences with the use of this approach could add general statements concerning system innovations towards transition in markets.
8.1.2 General findings for system innovation

As mentioned before, it will be hard to make statements regarding systems innovation in transition markets, but some remarkable points are noticed during this research. These will be stated and can be analyzed more in depth in further researches:

Firstly the effect of the influences of stakeholders during system innovations. Innovation is associated with a bright idea, a new technological improvement which will compete with the incumbent technology in a market. It seems that innovation is driven by mainly the technological improvement, rather than the influence of stakeholders/actors in the market. Using the STSc and the stakeholder analysis in this research, showed that the cooperations of actors in the LNG market will be more important than the development of for example the LNG driven engines or infrastructure. Hereby it can be noticed that the influence of stakeholders is important in system innovation in transition markets. Van de Kerkhof also showed in her study that within transition management, the proactive approach of changing institutional and socio cultural transformations will be essential (Kerkhof & Wieczorek, 2004). The introduction of LNG as marine fuel provides a solid causus to explore and elaborate the importance of stakeholder/ institutional influence in transition management more in depth.

Secondly it has been noticed that process design in the LNG market will be the key towards transitions in the shipping industry by introducing new cleaner fuels. This research showed that the market players in the shipping industry are not attracted to invest in LNG for now. They are inactive because of the many uncertainties in the market. New design of an approach is needed which could trigger market players to become more active and more trustable with LNG or other cleaner technology. Van Mierlo showed in her study an ““analytical framework for studying learning processes in the context of efforts to bring about system innovation by building new networks of actors who are willing to work on a change towards sustainable development”. (Mierlo, Smits, & Woolthuis, 2010) This framework could be used in the LNG market to bring actors together which could work together on a new business model for the industry. Further detailed research can be conducted to design a process approach specifically which can be used in system innovations.

8.2 Limitations of research scope

Another discussion point that could be addressed is the made suggestions for market players in the LNG system. Due the scope of the analysis, no detailed analysis could be conducted for each of the market player in the LNG system. The suggestions made are based on the conducted stakeholder and scenario analysis, but additional researches could be conducted, like detailed market and economic analysis for each market player specific. Insights gained from the interviews showed that a solid business tool for the shipping companies is missing. Thereby further research could be conducted for specific shipping companies active in the inland shipping to get more insights about which marine fuel will in the future (LNG, MGO, HFO SCR) economically be the best option for shipping companies. Engine companies and other organizations have conducted some basic analyses presented in this research, but these are not market specific and related to one specific shipping company. The interviewees also mentioned that these studies are missing for Dutch shipping companies.

The following discussion point can be made regarding the scope of this research. During the research the developments in North Europe have been used as a starting point. The focus was mainly on the shipping market in the Netherlands. During the research it was notable that LNG provided also opportunities in other industries, like LNG as fuel for trucks and the production of bio LNG in the Netherlands. In that perspective further analyses based on the feasibility of LNG use in other industries can be a good subject for further researches. Beside the opportunities in different industries, also opportunities in geographical different markets can be mentioned. During the literature study it has been noticed that LNG will play an important role in the energy supply of Japan for the coming decades. Also other East European countries are planning the build LNG import terminals in the near future. Because of time limits and scope of this research, the opportunities in other industries and geographical markets are underexposed.
Last point what could be indicated is that it could be interesting to research how engineering firms deal with innovation. The gained experiences form RH showed that also these types of big engineering firms can struggle to capture the new innovative ideas from the market.

8.3 FURTHER RESEARCH
Based on findings several further researches are suggested in this research. These are summed as follow:

- Extend STSc method with system dynamics modeling to analyze transitions in markets: LNG market, electric vehicles potential in the Netherlands, smart grids
- Explore business opportunities for LNG as marine fuel outside Europe
- Create new business models, to implement new clean technology in the shipping industry, for the whole logistical chain (for bunkering operators, shipping companies, ports and government)
- Create new process design for system innovation towards sustainable transition in markets.
- Explore business opportunities of bio LNG and LNG in other industries, like: LNG/bio LNG as fuel for trucks
- Explore how engineering firms can incorporate new innovations in their business strategies.
- Explore the system innovation in the car market towards electric vehicles with the TIP approach
9 ROYAL HASKONING

In chapter 6 possible strategies have been analyzed for important market players in the LNG system. The aim of this research was to make clear how players were positioned in the shipping market regarding LNG as marine fuel and how Royal Haskoning (RH) could respond to future developments. In this section possible future strategies will be presented for Royal Haskoning and recommendations will be given how they could approach the LNG system.

Firstly a short introduction of Royal Haskoning must be given to know more about this firm. RH is an internationally oriented consultancy firm with technical roots. Their core business is to develop solutions for issues related to the interactions between environment and people. RH provides multi-disciplinary services related to infrastructure and ports, industry and energy, water and environment, buildings and urban. With offices in 17 countries it is a global engineering consultancy firm with customers all over the world. Since 28-02-2012 RH has announced a possible merger with DHV, which will strengthen the global position of the firm in the future.

To get an understanding what RH can mean in the LNG system, the characteristics of the company regarding innovation must be given. Therefore the current situation how RH deals with new projects will be described. These observations are made by talking to several employees on the business floor during 6 months of working in the Heavy Industry & Logistics department.

9.1 CURRENT MARKET APPROACH OF ROYAL HASKONING

RH has built long trusted relationships with their customers. The experiences they have developed in the past 100 years provide them a trustable image in the engineering market. With highly skilled professionals in different business units, they service and provide sustainable solutions for their customers. At the current time, mainly new projects are attracted from clients they already have and the focus is mainly on to keep these relations in the future. New markets are penetrated by serving their clients who want to invest in new markets in different regions over the world. For example strategic cooperation is built with firms like Heineken. Innovation is seen as a process of serving the client and finding solutions for their goals and ambitions. Innovation can be conducted when it’s financed by an extern party and when the demand is from the market (Brink, 2012).

As mentioned before RH focuses to keep the relations with their customers and to extend these relations towards strategic cooperation. Penetrating other geographic market happens in several steps. Firstly a small project will be conducted for a client who needs the consulting services of RH. A further step is to extend these services to other projects of the client. When the clients trust RH, new bigger projects can be attracted. From this point, RH can become a strategic partner for that client. Finally RH can stabilize in that specific market and conduct other services for new clients. This is a global presentation how a new market is penetrated (Figure 31). Of course this pattern will not always be followed, but commonly this approach can be noticed.
RH is currently exploring business opportunities in the complex LNG system. This will be a hard process because at the current time RH is not familiar with LNG and has no experiences in the past. Therefore it will be interesting for this company to position in a new market and to find new opportunities in expanding their knowledge and business related to LNG. To deal with the situation and to come up with possible future strategies, a SWOT analysis will be conducted. The scenarios and stakeholder analyses conducted in this research will be used as input for the SWOT analysis. By coupling the strengths of the firm with the opportunities in the market, possible strategic roadmaps can be derived. The robustness of the strategies will be tested in the scenarios. Finally this will result in possible future strategies to position the firm in a complex LNG system.

The strengths of RH can be summarized by highly skilled professionals who can deliver solutions in the complex LNG system (Table 11). Their power lies in the knowledge and experiences they contain about designing dry-liquid bulk terminals, and all the logistics involved with transport and storage of these products. Besides engineering, RH could support market players in developing safety studies required for realizing small scale infrastructure for LNG bunkering. Next to safety designs, RH has the expertise to perform environmental studies to map the risks of projects to their environment.
Table 11 - SWOT analysis for RH in LNG system

<table>
<thead>
<tr>
<th>Objective</th>
<th>Helpful</th>
<th>Harmful</th>
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| Internal  | • Logistic chain approach  
• Design Terminals  
• Safety Studies  
• Engineering  
• Environmental Studies  
• Highly skilled professionals | • Lack of LNG (cryogenic) knowledge  
• Small timeframe to work on innovative ideas by professionals  
• Low budget for development new innovative concepts  
• Lacking approaching method for new innovative ideas |
| Strengths | Strengths | Weaknesses |
| External  | • Lack of knowledge regarding business models  
• Lack of expertise in small scale infrastructure  
• Unrealized bunkering infrastructure  
• Lack of standards and safety requirements for infrastructure  
• Possible demand for LNG infrastructure for short sea shipping and inland shipping | • Low demand for LNG in shipping industry  
• Low demand for small scale infrastructure  
• High LNG Price |
| Opportunities | Threats |

Looking at the weaknesses of the organization, some issues can be mentioned which were noticed while working on this research. These are observations and could also be misunderstood because the short period time of working in the company. First weakness which can be mentioned is the fact that no experts have cryogenic knowledge. Some people are interested and exploring the LNG market, but don’t have the expertise regarding LNG. When this research was started, I was looking for people within the firm to gain more knowledge regarding the involvement of the company in the LNG system. It was hard to build communication lines with the professionals. The lack of funds to finance innovative concepts is another weakness that can be mentioned. RH needs extern investments to make innovations or new conceptual ideas become reality. A final weakness is the lacking methods to approach new innovative ideas. Because the firm doesn’t conduct standardized work and each project differs, RH has a divisionalized organization structure according Mintzberg five-part theory. Each division has his own services and products within RH, but the work is conducted by highly skilled engineers. Therefore it can be understood that no fixed approaches exist to deal with innovation. On the other hand different views exist on how innovation can be incorporated within a firm. This falls out of the scope in this research.

Regarding the interviewees and analyses conducted in this research, several opportunities in the LNG system could be identified for RH. Based on the interviews it has been noticed that market players are missing expertise in developing or creating new business models for the future. The lacking knowledge and missing overall perspective towards the LNG system blocks them to develop new earning models for their operations. Secondly the lacking infrastructure for LNG provides opportunities for RH to think about designing small scale LNG concepts in the Netherlands. RH could do the design as well as the safety and environmental studies.
required to start up a network of bunkering stations. Another aspect which offers opportunities are the conceptual design of the logistics required to bring LNG from supplier to end consumer. Based on what has been said by experts and what is available in the literature, LNG bunkering will needed at the short term for inland shipping. Also the market of ferry lines has high potential to use LNG in the near future. Based on the scenario analysis, LNG as marine fuel will be attractive after 2020 in these markets. In that sense, the chances for RH will be to focus on the inland shipping market and ferry operating lines.

9.3 DRAFT STRATEGIES FOR ROYAL HASKONING

The experiences and knowledge will be the starting point to draft the strategies. The strengths of RH will be matched to the opportunities in the market. The knowledge gained from this research shows that opportunities are mainly at the infrastructure part in the LNG system. No to little experiences is valid regarding safety, environment and logistics of bunkering LNG stations. RH could focus at this part of the chain on the short term. The expectations of expert are that the inland shipping and ferry operators will need bunkering facilities on the short term. Bunkering operators are working to realize these facilities, but for now it seems that they are not capable by them own. The infrastructure subsystem of the LNG system consists of different parts which provide opportunities for market players. Therefore several strategies can be conducted by RH to approach the market.

9.3.1 NETWORK APPROACH

Firstly RH could position themselves within the network of active market players in the LNG system (Figure 32). This network approach will provide RH the opportunity to penetrate within the system and to have a better view of the demands and requirements of potential future clients. This approach requires an active positioning between the actors in the system and active cooperation in development projects in the coming years. This will require a solid team which will seek for the specific problems market players are facing and what they need to realize their goals regarding LNG. Thereby you could think about visits to network meetings and conferences, but this just an example how this strategy can filled in.

The advantages of this approach will be the low cost in investment within the firm. Keeping contacts and being active in a network will not require high initial costs. Beside the costs, this approach will provide a further knowledge in the requirements of market players, where market researches will not be sufficient enough to find that sort of information. A disadvantage could be that the lacking expertise of RH with LNG will be a barrier for the firm itself to penetrate in a network. Even if the cost expressed in money will be low, the time needed to deploy professionals will be high.

Looking at the scenarios, it can be said that this strategy will be robust in scenario 1 and 2. This strategy will be most successful if a high penetration of LNG in the market will take place at the short term. Even if this will not happen, the invested time and money will result in profits if scenario 2 will occur.
Another option what could be applicable for RH is the specific focus on services which could be delivered in the market. RH has the experiences in safety and environmental studies. From these experiences, services could be delivered in the market to realize bunkering infrastructure for LNG. This is presented in Figure 33. The realization of these facilities will happen with a high certainty, but the question remains when this will start in the Netherlands and in Western Europe. RH could invest in relationships with market players like Ports, bunkering operators and local governmental bodies whereby services can be offered in the market. Because RH has at the current time no expertise in LNG, the designing of facilities and logistics for LNG infrastructure will fall out of the scope. After stabilizing in the Dutch shipping market and having more experiences in LNG projects, RH could expand their business activities outside the Dutch borders.

An advantage of this approach is the fact that RH will conduct services which are less risky for the firm and provide services where enough experiences is valid in the firm. By using these experiences the penetration of the market will be more flexible and less risky than offering new services. Using their own services will lead to lower investments costs than acquiring new knowledge. Taking the scenarios into consideration, it can be noticed that this approach will be a robust approach at the short term. It is expected that LNG will have a slow start in the beginning and then expand after 2020. Penetrating the market by focusing on safety and environment will provide RH the basic grounds to expand in the future when the demand for LNG facilities will grow in the future. If this will not happen, they will be able to revise their business strategies hence the investments. Focusing on small penetration in the market will provide flexibility in the future and therefore be less risky. Also even when scenario 3 occurs where LNG will not play a significant role as marine fuel, this will still not have negative effects on RH.
9.3.3 Rough Approach

The last strategy that would be applicable for RH is to have a ‘rough approach’ towards the market (Figure 34). This means a strong positioning in the market by investing time and money in the coming years. Thereby a strong presentation of the firm can be done in the market, so other parties will be aware of their services. The outcome of this approach will be that the market will see RH as the experts regarding logistics and designing of LNG infrastructure. To achieve this reputation, more is required compared to the other two strategies. RH is now missing cryogenic knowledge to present them in the market so this gap can be filled before the market will be entered. This can be done by acquiring another small firm which has enough experience with LNG and related services. Another option is to attract professionals with LNG expertise.

After experience that could be done in the Netherlands, RH could use this knowledge to expand their businesses in the European and global market. This not only means that the company provides services for new customers, but also expanding their portfolio towards the market. Here you could think about designing larger LNG import terminals or designing liquefaction plants. Obviously this approach is more challenging and possibly will generate more money in the future compared to the other approaches. However it will require more investments which also lead to more risks for the firm. Beside the chance that the expected growth in LNG demand will not grow as expected, the competition in the market will also be rough. The other strategies are more cautious and waiting contrary to this rough approach. Also taking the three scenarios into account, it can be noticed that this approach is risky but have a greater potential compared to the other strategies. If a similar situation as in scenario 3 occurs, RH will have invested in a market with no potential. This can be risky, but this also can provide RH the opportunity to skip the focus in the Netherlands and totally focus on other global markets.
The different approaches are presented and now the question remains which approach will be fit the most to the firm’s characteristics and to the market potential.

**Figure 34 - Strategy 3: Rough Approach**

### 9.3.4 POSSIBLE STRATEGIES VERSUS RH MARKET APPROACH

It will be a hard decision for RH to conclude whether they will see LNG as a potential business to focus on in the near future. Not only because of the uncertainties in the complex environment, but also internal factors will influence this decision. If the different roadmaps are compared to the culture of the firm, it can be concluded that strategy 3 will be hard to execute. As described in section 8.1, RH approaches new markets by conducting small projects for their clients. Also there is not a big budget to finance these types of new projects. It is questionable whether this strategy is feasible or not for the firm itself. Besides the financial aspects of the strategy, the faith and awareness in the potential of LNG must exist within the strategic management and professional staff of the firm. This awareness of the innovative potential in LNG is not applicable for the mainstream professionals in the organization.

Strategy 1 and 2 fits more to the current RH culture and can be understood better by the decision makers and business developers within the firm. Also the financial budget required to follow this strategy falls within the used project budgets. In that sense the organization will probably see more potential in strategy 1 and 2 which will be more trusted compared to strategy 3 regarding the finance and scope of the projects.

The methodologies used in this research to explore the potentials in the market provided insights in the developments of the market. Three possible scenarios are described and several others could be added to this research. Before the research started, the main question was whether LNG could provide opportunities for RH.
During the research it becomes obvious that sooner or later LNG would be a business with potential in the near further. Therefore RH must from now on not question whether they will ‘do something with LNG’, but take the following step and think seriously about business models. A first step is conducted by exploring alternative strategic roadmaps, but this can of course be extended with other valuable strategies. As can be noticed by experiences during this research, LNG doesn’t play any role within the organization. RH is obviously lacking behind in the market and this will influence the possible future positioning in the market.

Beside it will be crucial to know where the focus must be regarding the opportunities in the LNG system, the decision makers of RH must be aware that the firm must first be open to LNG related businesses. For now, the company is in an orientating phase and in that perspective it can be understood that also RH is in a wait and see position. Though waiting long in a highly complex and fast developing market will lead to missing opportunities in the future. Therefore it can be recommended that it would be wise to make clear decisions whether LNG business will be a ‘go’ or ‘no go’ for the coming years. As it is been noticed during the research many firms are active and delivering new services and presenting themselves as a well experienced LNG ‘know how’ partner. This shows that they are in a process which could lead to new business with other market players, by only being active in the process itself. Also small companies with lower financial budgets are in a way open towards LNG innovation and try to settle in a network of bigger market players. These dynamics in the system shows that RH must in a short term be clear towards their own organization regarding LNG. If this step is taken, then the professionals of the firm could start to think about which businesses would be interesting for RH, taking this report as a starting point.

9.4 RECOMMENDATIONS FOR ROYAL HASKONING
Based on the different approaches RH could apply in the future, a summarized strategic roadmap will be recommended. This will help the decision makers of RH in the beginning stage towards new LNG business concepts in the future.

- Define project group for LNG business (in and between different business lines within the company)
- Create initial business concept for small scale LNG bunkering infrastructure: **Total design of logistic chain** (transport, storage and bunkering of LNG), development of standards for bunkering & safety and standards for environment permits.
- Lobbying: launch RH as LNG partner in the market. Participation of members of the LNG group at conferences, meetings and clients to promote RH as partner with LNG businesses. Organize at the firm LNG conference where market players could participate.
- Gather more information about the LNG demand from the market. Then update initial business concept taking the demand from the market into account.
- Evaluate if new LNG expertise is needed within company.
- Launch the new LNG business concept at current and new clients. Find client to initiate and implement business plan.
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Appendix 1 Interview Gas Transporter

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  
  Business developer

- Wat zijn de doelen van the gas transporter m.b.t. LNG en waarom? Welke projecten zijn ze betrokken?
  
  Aanleveren van LNG binnen en buiten Europa aan customers. Doel is meer schepen die LNG vervoeren, dus realiseren van volume in de markt. Leveren van LNG: small scale. Dienst verlenen aan klanten, zodat zij niet schepen hoeven aan te schaffen om LNG te importeren.

Positie Reders en technologische toepassingen

- Wat zullen de enabelers zijn voor marktpartijen om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?
  
  o Betrouwbaarheid technologie?
  o Kosten?
  o Prijs LNG?
  o Veiligheid kwesties? NEN?

Prijs LNG is op dit moment aantrekkelijk. Dit kan in de toekomst veranderen: goedkoper worden wanneer het losgekoppeld wordt van olie.

- Welke factoren belemmeren marktpartijen om te investeren in LNG op dit moment?
  
  o Technische barrières: opties voor bunkering, opslag en transport?
  o Infrastructuur? Sunk kosten?
  o Gebruikers voorkeuren? Hoe denken de rederviers en havens hierover?
  o Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  o Wetgeving

  o Politieke onduidelijkheid
  o Extra kosten: hogere CAPEX
  o Afwezigheid infrastructuur voor LNG bunkeren. Supply zekerheid is er niet.

- Wat zijn mogelijke oplossingen om barrières weg te nemen?
Wetgeving moet duidelijkheid bieden aan marktpartijen. Nu bestaat er een optie om de wetgeving nog strenger te maken dan al is aangekondigd. Hierin moet meer duidelijkheid komen.

Op dit moment mogen er geen schepen op LNG varen in binnenvaart. Dit moet allemaal worden bekeken en aangepast.

Sturingseffecten realiseren: wetgeving en een actievere houding van overheid en andere marktpartijen.

- **Hoe wordt de positie van andere betrokkenen m.b.t. LNG in de scheepvaart industrie gezien?**

  MDO is een duur brandstof wat wel aan de eisen zou kunnen voldoen in 2015. De prijs voor diesel voor auto’s zou kunnen toenemen wanneer de scheepvaart grootschalig hierop overgaat. HFO met scrubbers is een alternatief met onzekerheid hoe om te gaan met waste. Daarnaast vergen de scrubbers ook additionele kosten. Geen testcases tot nu toe dus onduidelijkheid.

- **Welke markten hebben de meeste kans op schepen met LNG? Binnenvaart, kustvaart, publieke transport, visserij?**
  - Binnenvaart vaste route, onduidelijk waarom nu zo weinig schepen zijn die aangepast zijn om op LNG te varen.
  - Met dual fuel motoren kan er eveneens langere afstanden worden afgelegd.

**Actoren/strategie**

- **Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?**
  
  Shell en State oil: de olieproducenten zullen zeker een grote rol spelen. Olievoorraad nemen af en gas wordt steeds aantrekkelijker gezien de voorraden van gas in de wereld.

- **Welke allianties kunnen marktpartijen m.b.t. LNG in de scheepvaart?**

- **Op welke factoren denkt gas transporter te kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van the gas transporter in de keten?**
  - Leveren van small scale LNG aan customers.

**Trends**

- **In welke markten zal LNG een kansrijke toegang hebben?**
  1. Binnenvaart; next alternatief is MGO en dat is vrij duur
  2. Wegverkeer: goedkopere alternatief en de markt is er klaar voor.
  3. Short sea shipping: ferries hebben vaste routes. Wanneer bunkeren in verschillende landen mogelijk is, zal hier LNG als brandstof ook gebruikt worden.

- **Hoe ziet the gas transporter de markt voor de komende 10 jaar?**
Prijsonzekerheid: LNG moet gekoppeld worden aan next alternative: HFO bijvoorbeeld waardoor meer zekerheid gerealiseerd kan worden.

Nieuwbouw schepen zullen meer op LNG varen, opdat de kosten dan veel lager zijn dan bij ombouwen van de huidige schepen.

- Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?

EU en Nederlandse overheid staan heel positief tegenover LNG en geeft de voorkeur aan deze alternatief. De prijsontwikkeling van LNG in de wereld zal een belangrijke rol spelen. In Vs is shale gas losgekoppeld aan olie en zal Amerika binnenkort als LNG exporteur opereren omdat ze goedkoop gas produceren door fracking. Dit gebeurt in Europa niet, maar later zal het een rol gaan spelen. Dit zal allemaal van invloed zijn op supply van LNG en de prijsontwikkeling. De reden waarom LNG aantrekkelijk is, omdat de OPEX voor schippers lager is vergeleken met conventionele brandstoffen. Wanneer de prijs van LNG stijgt, zal dit grote gevolgen kunnen hebben.

- Welke brandstof alternatief zal de meeste kans van slagen hebben?

Dual fuel: hierdoor kunnen de risico’s om te bunkeren in andere landen waar geen LNG beschikbaar is, te verminderen.

- Welke rol kan Royal Haskoning betekenen in de markt?

  - Overheid ondersteunen van advies
  - Vergunningen
  - Ontwerpen van proces: logistieke keten voor klanten in kaart brengen. Ondersteunend advies.
Appendix 2 Interview Bunkering Operator A

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  
  Business Developer: Op dit moment voornamelijk bezig met LNG.

- Wat zijn de doelen van bedrijf A m.b.t. LNG en waarom?
  - Leveren van LNG aan eindgebruikers d.m.v. bunkerponton
  - Investeren in LNG infrastructuur

Positie bedrijf A en technologische toepassingen

- Gezien de huidige supply chain van LNG, waar zou u positie in de waarde keten als bedrijf nu willen innemen?
  - Productie>liquefaction>shipping>terminal>distribution>end-user?
    Distributie: leveren van LNG aan eindgebruikers.
  - Waar in de toekomst?
    Partner NorthSea Group: Opslag van LNG: Drijvende opslag terminals, inland terminals over 8-15 jaar.

- Wat zullen de enabelers zijn voor bedrijf A om te investeren in LNG toepassingen, zoals opslagtanks, bunkeringfaciliteiten?
  - Betrouwbaarheid technologie? Technologie is aanwezig, geen belemmering.
  - Kosten? Financiële randvoorwaarden vormen geen obstakel.
  - Prijs LNG? Hoofddriver voor de komende 5-10 jaar. Meer gas zal via Europese terminals Europa binnen komen, wat invloed zal uitoefenen op de gasprijs.

- Welke factoren belemmeren bedrijf A om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?

Op dit moment is er geen wetgeving m.b.t. LNG. Dit zorgt voor de grootste barrière: Onduidelijkheid hoe infrastructuur in te richten. Onduidelijk aan welke veiligheidseisen te voldoen. Organisatorisch, de samenwerking tussen marktpartijen laat wensen over.
De aanwezigheid van de vraag in de markt naar LNG zal de afbreuk risico van de investeringen verlagen.

Er zijn technische barrières: het ontbreken van beleid en duidelijke regelgeving zijn de factoren die op dit moment belemmerend werken.

- Wat zijn mogelijke oplossingen om barrières weg te nemen?
  Samenwerken met andere partijen in de markt. Alle partijen dienen actief te zijn. De overheid moet stappen maken om de regelgeving m.b.t. LNG te verwezenlijken.

- Kan bedrijf A een rol spelen bij het mogelijk maken van LNG als brandstof voor de scheepvaart?
  - Zo ja, in wat voor opzichte?
    Leveren van LNG aan de schepen: Opzetten van infrastructuur voor bunker. 

- Hoe wordt de positie van andere betrokkenen m.b.t LNG in de scheepvaart industrie gezien?
  Volume in de markt dient gecreëerd te worden om LNG als brandstof in de scheepvaart een succes te maken. Hierin zullen de rederijen een rol spelen: zij zijn voor bedrijf A de markt die ze zullen voorzien van LNG.

**Actoren/strategie**

- Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?
  De overheid kan tegenwerken door later de LNG prijs met accijns te verhogen. Op dit moment zijn ze op de achtergrond, maar later kunnen ze de markt tegenwerken.

- Welke allianties kan bedrijf A vormen m.b.t. LNG in de scheepvaart?
  - Welke samenwerkingsverbanden zijn al gevormd?
    - LESAS project met TNO: Veiligheidseisen m.b.t. LNG bunkeren
    - PGS 33 m.b.t. LNG tankstations samen met NEN normcommissie.
    - Port of Rotterdam: Ship to ship bunkering veiligheidscenario’s.
  - Toekomst?
    - Partnerschap om wetgeving en veiligheidsnormen te bewerkstelligen.

- Hoe ziet bedrijf A de eigen positie in een mogelijk toekomstige LNG markt?
  - Wie zijn de klanten?
    Eindgebruikers van LNG: scheepvaart wordt op dit moment gezien als de markt waar de vraag de komende jaren zal ontstaan en zal toenemen. Bedrijf A wil op deze vraag vanuit de scheepvaart inspelen d.m.v. bunkerfaciliteiten.

- Op welke factoren (kosten infra, bunkering, motoren) denkt bedrijf A te kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van Argos in de keten?
  - Realiseren van bunkerfaciliteiten voor de scheepvaart zal door bedrijf A een toegevoegde activiteit zijn in de waardeketen.
  - Logistieke activiteiten m.b.t. leveren van LNG aan eindgebruikers.
Trends

- In welke markten zal LNG een kansrijke toegang hebben? (scheepvaart, vrachtwagens, energy supply Nederland)

  Bedrijf A zal zich de komende jaren eerst focussen tot de scheepvaart: voornamelijk binnenvaart. Ook de kustvaart biedt veel kansen door komst van SECA gebieden.

  De focus ligt op dit moment niet op de uitrol van LNG vulstations voor vrachtwagens bijvoorbeeld.

- Hoe ziet bedrijf A de markt voor de komende 10 jaar?

  Onzekere politieke arena komende jaren. Ook de crisis heeft hier invloed op.

  Begin 2013 verwacht men eerste LNG schepen van brandstof te voorzien. Daarna is de verwachting dat volume in de markt gaat toenemen.

  Gezien de ontwikkelingen in Europa, heeft Nederland baat bij om spoedig te handelen m.b.t. wetgeving en veiligheidseisen voor de LNG keten. Dit omdat andere omliggende landen eveneens bezig zijn om LNG als brandstof te gebruiken. Hierdoor heeft Nederland baat bij om sneller te handelen zodoende de eigen concurrentie positie t.o.v. andere omliggende landen (België, Frankrijk) te versterken.

- Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?

  Actieve houding van marktpartijen: op dit moment is er weinig beweging en hierin moet verandering komen. Daarnaast zal de overheid betrokken moeten raken en de regelgeving zo snel mogelijk moeten aanpassen m.b.t. gebruik van LNG als brandstof in de scheepvaart.
Appendix 3 Interview Ship Builder

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  R&D afdeling, project engineer

- Wat zijn de doelen van schepenbouwer x m.b.t. LNG en waarom?
  Voldoen aan de vraag nu en in de toekomst van de klanten (rederijen). Als scheepswerf kijk je naar de vraag in de markt. De vraag is op dit moment niet gedetailleerd.

Positie schepenbouwer en technologische toepassingen

- Wat zullen de enableurs zijn voor schepenbouwer x om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?
  - Betrouwbaarheid technologie?
  - Kosten?
  - Prijs LNG?
  - Veiligheid kwesties? NEN?

  Prijs> 3 tot 4 factor hoger (voor de componenten)

- Welke factoren belemmeren schepenbouwer x om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  - Wetgeving

De technologie is aanwezig. Echter moeten er duidelijkheden komen vanuit de wetgeving m.b.t. de ontwerpeisen van de schepen. Dit is op dit moment een barrière. Mochten nu schepen worden gebouwd en deze na de komst van nieuwe regels niet voldoen aan de eisen, zal dit voor de onderneming economische schade opleveren. Dit is op dit moment een groot risico.

IMO is met het ontwikkelen van codes bezig. Gaan deze standaarden door alle landen worden overgenomen, of zal per land nieuwe standaarden worden ontwikkeld? Dit is nog onduidelijk.

Daarnaast is het van belang dat de kosten voor de onderdelen van de schepen dalen. Hier hebben we het over de motoren en de tanks.

Afwezigheid van bunkerstations is niet de zwakste schakel aangezien partijen nu bezig zijn of hebben toegezegd deze te realiseren.
• Wat zijn mogelijke oplossingen om barrières weg te nemen?
  o Snelle introductie van wetgeving
  o Kosten kunnen dalen wanneer de tussenpersonen tussen de schepenbouwer en producenten minder worden. (Directe levering)
  o Incentives om de aanschaf te stimuleren of anders regelgeving die verplicht op LNG schepen te varen. Dit omdat de schepen veel duurder worden (factor3/4)

• Hoe wordt de positie van andere betrokkenen m.b.t LNG in de scheepvaart industrie gezien? Hoe kijken de rederijen hierna?
  o Rederijen zullen een belangrijke positie innemen. Zij zullen uiteindelijk de vraag in de markt bepalen. Wanneer zij vertrouwen zullen hebben in de technologie, kunnen zij de stappen nemen om LNG als brandstof te gebruiken.
  o Markt moet transparanter, informatiedeling> meer samenwerken. Motorleveranciers moeten meer kennis delen.

• Hoe zal de markt de komende jaren in Nederland zijn en in Europa? Wat is de marktpotentie voor schepen op LNG?
  o Op dit moment geen orders, maar aanvragen van klanten.

• Welke markten hebben de meeste kans op schepen met LNG? Binnenvaart, kustvaart, publieke transport, visserij?
  o De binnenvaart is een innovatief markt, die meestal als broker kan optreden. Verwachting is dat de binnenvaart de eerste stappen zal nemen.
  o Ferry’s en sleepboten: vaker bunkeren zal geen probleem zijn.
  o Als laatste cargo transport wereldwijd: initiële kosten hier hoger.

Actoren/strategie

• Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?
  Klassebureaus zullen belangrijk worden. Deze zullen voortrekkers zijn in regelgeving/eisen/standaarden voor de schepen.

• Welke alianties kan schepenbouwer x vormen m.b.t. LNG in de scheepvaart?
  o Welke samenwerkingsverbanden zijn al gevormd?
  o Toekomst?
    Joint projecten met componenten leveranciers, rederijen en klassebureaus. E3 projecten> haalbaarheidstudies.

• Hoe ziet schepenbouwer x de eigen positie in een mogelijk toekomstige LNG markt?
Afwachtend op dit moment, geen prioriteit om in LNG schepen te investeren.

- Op welke factoren denkt schepenbouwer x te kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van schepenbouwer in de keten?
  - Aanschafkosten voor LNG schepen. Onderhoudskosten reduceren.

**Trends**

- In welke markten zal LNG een kansrijke toegang hebben?
  - Binnenvaart. Durven meer risico’s te nemen.

- Hoe ziet schepenbouwer x de markt voor de komende 10 jaar?
  - Gezien de huidige wetgeving, kan beter HFO met scrubbers worden gebruikt: goedkoper dan LNG
  - Huidige dual motoren zullen niet allemaal voldoen aan de TIER 3 eisen.
  - Volledig gas is een beter oplossing dan dualfuel. Voor klanten is het handiger op meerdere brandstoffen te varen. (dit omdat niet overal bunkerfaciliteiten zullen zijn en of is er wel de juiste LNG kwaliteit)
  - De wetgeving zal binnen 3/5 jaar komen. Daarnaast zullen de eerste schepen binnen 10 jaar wel varen.

- Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?
  - Prijsontwikkeling van LNG zal belangrijk zijn. Wanneer nu naar de ontwikkelingen in Japan wordt gekeken, is de kans groot dat het land zal kiezen voor LNG en kernenergie afbouwen. Dit zal invloed hebben op de prijs. Door een onduidelijke prijs is er op dit moment geen verdienmodel voor actoren te bedenken.
  - Wetgeving
  - Vertrouwen in de technologie zal belangrijk zijn voor de rederijen. Zij willen niet als eerste de risico’s nemen.
Appendix 4 Interview Knowledge Institute

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Algemeen

- **Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?**
  
  Professor

- **Wat zijn de doelen van TUDelft m.b.t. LNG en waarom?**

  Studenten begeleiden bij afstudeerprojecten

- **Gezien de huidige supply chain van LNG, waar zou u positie in de waarde keten als bedrijf nu willen innemen?**

  Integrator van kennis

- **Wat zullen de enabelers zijn voor actoren om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?**

  o Betrouwbaarheid technologie?
  o Kosten?
  o Prijs LNG?
  o Veiligheid kwesties? NEN?
  o Kosten moeten aantrekkelijker worden voor reders om over te gaan op LNG. Nu is de instap risico hoog. Ook omdat er geen faciliteiten zijn om LNG te bunkeren. Kip en ei verhaal

- **Welke factoren belemmeren actoren om te investeren in LNG op dit moment?**

  o Technische barrières: opties voor bunkering, opslag en transport?
  o Infrastructuur? Sunk kosten?
  o Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  o Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  o Wetgeving

  Wetgeving is afwezig op dit moment. Hierdoor onduidelijkheden aan eisen voor schepen. Ook ontbreken laadfaciliteiten

- **Wat zijn mogelijke oplossingen om barrières weg te nemen?**

  Overheid moet als launching customer optreden. Subsidies voor bedrijven beschikbaar maken.
Hoe wordt de positie van andere betrokkenen m.b.t. LNG in de scheepvaart industrie gezien? Hoe kijken de rederijen hierna?


Hoe zal de markt de komende jaren in Nederland zijn en in Europa? Wat is de marktpotentie voor schepen op LNG?

Schepen op dualfuel motoren zijn kansrijk. Door deze motoren wordt een hogere flexibiliteit behaald: daar waar je geen LNG kan bunkeren, kan je varen op olie.

Welke markten hebben de meeste kans op schepen met LNG? Binnenvaart, kustvaart, publieke transport, visserij?

Ferry’s is een kansrijke optie: de vaarroutes zijn bekend, dus de bunkerfaciliteiten neerzetten zal geen lastig verhaal zijn. Qua veiligheid zal een ferry niet een hoger veiligheidsrisico hebben omdat het personen vervoert: dit omdat je minder brandstof hoeft mee te nemen aan de schepen.

Actoren/strategie

Welke allianties kunnen bedrijven vormen m.b.t. LNG in de scheepvaart?

Allianties om de wetgeving mogelijk te maken. Meer test-cases te realiseren.

Hoe ziet de TU Delft de eigen positie in een mogelijk toekomstige LNG markt?


Trends

In welke markten zal LNG een kansrijke toegang hebben?

- Ferry’s en schepen met een vaste route: baggerschepen, sleepboten.

Hoe ziet de TU Delft de markt voor de komende 10 jaar?


Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?

Ontwikkeling van wetgeving en het beschikbaar maken van laadfaciliteiten voor schepen.
Appendix 5 Interview Umbrella Organization Ports

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Algemeen
- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
- Wat zijn de doelen van Umbrella Organization Ports m.b.t. LNG en waarom? Welke projecten zijn ze betrokken?

Samenbrengen van marktpartijen. Integreren van kennis en opzetten van gezamenlijke onderzoeken.

Positie Reders en technologische toepassingen
- Wat zullen de enabelers zijn voor marktpartijen om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?
  - Betrouwbaarheid technologie?
  - Kosten?
  - Prijs LNG?
  - Veiligheid kwesties? NEN?

Emissie eigenschappen en lagere OPEX van LNG als brandstof.
- Welke factoren belemmeren marktpartijen om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  - Wetgeving

  - Veiligheidsaspect in de markt gerelateerd aan LNG. Door miscommunicatie is er een verkeerd perceptie over LNG: vaak wordt het geassocieerd met LPG.
  - Regelgeving ontbreekt: onzekerheid
  - Maakindustrie, zoals motorfabrikanten en leveranciers van sub componenten zien niet klaar om LNG als brandstof voor scheepvaart mogelijk te maken: te dure componenten.

- Wat zijn mogelijke oplossingen om barrières weg te nemen?
  
  Fiscale instrumenten, len faciliteiten voor reders.

  Een nieuwe ketenbenadering moet door marktpartijen worden opgezet zodat de reders de meerkosten voor extra investeringen kwijt kunnen. Nieuwe verdienmodellen moeten worden bedacht. Nu kunnen de reders de meerkosten voor de investeringen als motor en LNG tanks niet verrekenen.

- Hoe wordt de positie van andere betrokkenen m.b.t LNG in de scheepvaart industrie gezien?
Afwachtend. Passieve overheid.
Leveranciers met hoge offerten.

- Hoe zal de markt de komende jaren in Nederland zijn en in Europa? Wat is de marktpotentie voor schepen op LNG?
LNG zal zijn introductie doen. 5000/6000 binnenvaart schepen: grote marktpotentie.

- Welke markten hebben de meeste kans op schepen met LNG? Binnenvaart, kustvaart, publieke transport, visserij?
  - Binnenvaart: grootte van motoren, stationeren van bunkerfaciliteiten op middellange afstanden.

**Actoren/strategie**

- Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?
  Shell is en blijft een grote speler. Meeste LNG komt van hen.

- Welke allianties kan Rederijen vormen m.b.t. LNG in de scheepvaart?
  Keten bij elkaar brengen. Nieuwe verdienmodellenrealiseren

- Op welke factoren denkt Umbrella Organization Ports te kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van Umbrella Organization Ports in de keten?
  - Samenbrengen van kennis.

**Trends**

- In welke markten zal LNG een kansrijke toegang hebben?
  Voornamelijk binnenvaart als eerste stap. Vervolgens wanneer infrastructuur voor bunker in andere landen is gerealiseerd: short sea shipping.

- Hoe ziet Umbrella Organization Ports de markt voor de komende 10 jaar?
  LNG zal zeker zijn introductie doen. Wetgeving zal nog verder moeten ontwikkelen. De maakindustrie zal met betere offerten moeten komen.

- Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?
  Prijs van LNG. Zal de overheid later accijns verrekenen?

- Welke brandstof alternatief zal de meeste kans van slagen hebben?
  LNG zal tegen de 2030 wel als een belangrijk scheepvaart brandstof worden gezien.

- Welke rol kan Royal Haskoning betekenen in de markt?
Appendix 6 Interview Engine Producer

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- What is your function within engine producer x?

LNG Fuelled Marine Systems
Technological and Business Development
Campaign Manager - Europe

- What are the purposes of engine producer x regarding LNG as fuel for ships?
  - Focussing on environmental friendly marine solutions based on widest range of products: propulsion systems, ship design and engines.
  - Deliver motor engines for future LNG vessels.

- Which factors will enable engine producer x to invest more in LNG?
  - Maturity of technology
  - Costs?
  - Flexibility
  - Safety issues?

Increasing oil prices will make gas fuelled ships interesting. Also the new regulations regarding NOx and Sulphur will enable RR to focus more on gas engines.

- Which factors can be seen as barriers for firms to invest in LNG?
  - Costs?
  - Technical barriers
  - Infrastructure
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - The policy of governments?

Technical

- Which types of engines does engine producer x produce?
  Bergen types: Liquid fuel, spark ignited lean-burn gas engine

- Which MH number is needed for these engines? How will engine producer x deal with quality of LNG?
  70, competitors cannot go below 80.

- How is the performance compared to diesel and HFO with scrubbers?
Only gas engines: no knocking effects as it’s occur with dual fuelled engines. Since we can handle a MN 70, actually we do not have any problems any of the LNG blend available worldwide.

- **How will be the cost compared to other alternatives?**
- **How do engine producer x deals with knocking effects of the engines?**
  The focus will be on gas engines. No knocking effects will occur.
- **Will dual engines the first best alternative, the next move in the market as fuel for vessels?**
  No, DF technology would be a temporary solution for those shipping scenarios where the LNG availability at a competitive price will NOT be available, yet. DF could be a possible solution for long haul shipping scenarios with no regular trading.

**Actors & Strategy**

- **What is the added value of engine producer x within this new LNG market for ships?**
  Deliver engines which can deal with the lowest quality of LNG. Deliver marine solutions for customers which will support a possible transition towards vessels on gas.
  Highest efficiency, simplest solution, - one stop bunkering - lowest emissions, easiest installation + 40 years experience on gas engines

- **How sees engine producer x the position of other players in the market?**
  - Who have the power in the market?
  - Which will lead in this market?
  Confidential

- **Which parties doesn’t have an important role in the current situation, but will be important in the near future?**
  Confidential

- **Which partnerships has engine producer x formed regarding LNG?**
  - Which partnerships will it form in the future or want to form?
  Confidential

- **How sees engine producer x his position in the market?**
  - Who are the partners?
  - The main competitors?
  - The customers?
  Confidential

**Trends**

- **How do you see the market within 10 years?**
  The market will be very much depending on the availability of small/mid supply chain availability, and consequently an attractive LNG price. The further inclusion of the Mediterranean, Marmara sea as ECA areas will be an additional reason for moving to LNG as fuel.
Appendix 7 Interview Research Institute

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  Business developer

- Wat zijn de doelen van kennisinstituut m.b.t. LNG en waarom?
  LESAS: toeleveringsketen, aanbevelingen aan de overheid m.b.t. wetgeving >Safety studies. Helft gefinancierd door overheid, de andere helft industrie.
  -STS transfer ook binnen de LESAS. Offshore bunkering + tankplaatsing voldoende kennis en om dit voor LNG toe te passen.

- Wat zullen de enabelers zijn voor actoren om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?
  - Betrouwbaarheid technologie?
  - Kosten?
  - Prijs LNG?
  - Veiligheid kwesties? NEN?


Brandstofprijzen zullen doorslaggevend zijn: trend is dat olie lastiger in de toekomst en gas is nog voldoende. De verhouding is dat het goedkoper is dan olie en ook losgekoppeld zal worden.

- Welke factoren belemmeren actoren om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  - Wetgeving

Afwezigheid van veiligheidseisen van schepen + opslag en bunkering m.b.t. risico’s.

Maar na dit, voldoen de plekken de aangewezen plekken voor de binnenvaart + short sea shipping? Veiligheid limiteert de posities van mogelijke bunkerfaciliteiten.
Collectiviteitbeginsel is minder. De overheid laat het over aan de markt.

- **Wat zijn mogelijke oplossingen om barrières weg te nemen?**
  Meer testcases om uit te zoeken welke risico’s bij verschillend laadfaciliteiten/overslag en opslag opties aanwezig kunnen zijn.
  Investeringen voor infrastructuur vanuit de overheid.

- **Hoe wordt de positie van andere betrokkenen m.b.t. LNG in de scheepvaart industrie gezien? Royal haskoning?**
  Case rond small scale is interessant.
  Economy of scale door kosten vroeger interessant. Inspelen op de vraag in de markt. Bussines case ontwikkelen voor onshore voor lange termijn afgifte (contract voor gaslevering). Daarnaast denken aan multifunctionaliteit.
  Na standaardisatie van veiligheidseisen, zal dit minder interessant zijn voor RH.
  Vanuit milieu aspecten, small scale heeft een betere promotie aspect. Met pijpleiding heb je een milieutechnisch nadeel vergeleken met LNG levering. Small scale supply hierdoor interessant.

- **Hoe zal de markt de komende jaren in Nederland zijn en in Europa? Wat is de marktpotentie voor schepen op LNG?**
  Infrastructuur kant investeringen gedaan worden door de overheid.

**Actoren/strategie**

- **Positie van andere actoren?**
  Wie geeft de vergunningen: dat is belangrijk. Havenbedrijf met reglementen. Hoe ga je de overslag van panton zien? Als een vaste installatie of als een outland installatie.
  o Grotere rederijen werken niet met koepelorganisaties, kleinere bedrijven zitten daar meer.
  o Anthony veder: interessant omdat ze aan de levering kant zitten van LNG + mogelijk op LNG kunnen varen.

- **Welke allianties kunnen bedrijven vormen m.b.t. LNG in de scheepvaart?**
  Logistieke keten moet worden opgezet.

- **Hoe ziet hetkennisinstituut x de eigen positie in een mogelijk toekomstige LNG markt?**
  o Stichting om LNG activiteiten te promoten
  o Inzichten in waar de industrie naar toe wil gaan

- **Bio LNG?**

Voorlopig geen standaarden voor LNG kwaliteit, dus de toegevoegde waarde is op dit moment de vraag. Diesel heeft een ontwikkeling gemaakt, dit zal ook gebeuren met LNG.

- **Grote spelers?**

  Niet meekunnen gaan in de small scale projecten. Landen zoals Litouwen bijvoorbeeld zullen in de toekomst LNG kunnen ontvangen. Er zijn geen designs/logistieke ketens voor small scale infrastructuren waar de pijpleidingen in dat soort landen te hoog zijn. Dit soort infrastructuur heeft nieuwe veiligheidseisen/standaarden nodig wat nog niet ontwikkeld is. Dus de kennis die bedrijven op dit moment hebben kunnen niet 1 op 1 worden overgedragen. Hier zijn de kansen aanwezig.

**Trends**

- **In welke markten zal LNG een kansrijke toegang hebben?**


  Ferry’s ook interessant: de discussies die aanwezig zijn: mag je bunkeren wanneer mensen op de ferry’s aanwezig zijn. Deze discussies kunnen m.b.t. berekeningen helderder worden. Lijndiensten zijn uitermate interessant.

- **Hoe ziet het kennisinstituutx de markt voor de komende 10 jaar?**

  Aangetoonde olievoorraden zijn weinig voor olie: hier zie je geen beweging, weinig investeringen.

  Scrubbers dure aanpassing Weinig investeringen in raffinage: scrubbers. Residuen worden gebruikt in powerplants of schepen. Gunstiger om residuen in powerplants af te zetten

  Na 2015 zal een benzine diesel verhouding ontstaan. Bedrijven zullen omvallen die niet goed participeren.

  Grotere rederijen kunnen de opties bekijken, omdat ze een grotere capaciteit hebben. Visie is belangrijk. Kleinere bedrijven

- **Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?**

  Decentrale infrastructuur zal interessanter zijn omdat overheid afstapt van het collectiviteitbeginsel.

  Small scale in Noorwegen door geografische reden nu interessant maar wanneer de markt is ontwikkeld, zal pijpleiding goedkoper zijn.

  LNG moeilijk concurreren met pijpleiding gas.
Appendix 8 Interview Ship-owner Association

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  Operationele zaken (milieu en technische zaken).

- Wat zijn de doelen van koepelorganisatie x m.b.t. LNG en waarom? Welke projecten zijn ze betrokken?
  - Lobbyen namens de reders
  - Belangen behartigen van reders (95% Nederlandse reders)
  - Verschillende opties voor brandstoffen inzichtelijker maken
  - Regionale wetgeving

Positie Reders en technologische toepassingen

- Wat zullen de enabelers zijn voor Reders om te investeren in LNG toepassingen, zoals bouwen van schepen of offshore toepassingen?
  - Betrouwbaarheid technologie?
  - Kosten?
  - Prijs LNG?
  - Veiligheid kwesties? NEN?

MGO is duur alternatief. Daarnaast is HFO met scrubbers geen bewezen technologie. Enkele partijen zijn ermee bezig, maar een behoorlijke investering. Wat doen we met afval? Veel onduidelijkheden hier. Hierdoor zijn er kansen voor LNG als brandstof voor de reders.

- Welke factoren belemmeren rederijen om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?
  - Wetgeving

- LNG bunkering moet aanwezig zijn. Reder moet zekerheid hebben dat het LNG kan bunkeren.
- Eisen voor LNG schepen zijn niet duidelijk: IGF (international code for gas fuelled ships) code ontwikkeling is nodig
- Procedures om te bunkeren zijn ook niet duidelijk
Jonge Nederlandse vloot op dit moment. LNG zal een rol spelen voor nieuwbouw.

Wat zijn mogelijke oplossingen om barrières weg te nemen?

Hoe wordt de positie van andere betrokkenen m.b.t LNG in de scheepvaart industrie gezien?
DNV heeft regels opgesteld bij gebrek aan internationale regels.
Klasse bureaus zullen wel met eigen komen, echter zullen de standaarden vanuit de IMO (IGF code) doorslaggevend zijn.
Daarnaast dienen personeel moeten worden bijgeschoold m.b.t. opleidingen. Dit is ook een reden waardoor reders nog afwachtend zijn.

Hoe zal de markt de komende jaren in Nederland zijn en in Europa? Wat is de marktpotentie voor schepen op LNG?
Een aantal reders hebben berekeningen uitgevoerd.

Welke markten hebben de meeste kans op schepen met LNG? Binnenvaart, kustvaart, publieke transport, visserij?
Short sea shipping is kansrijk (gezien vanuit de onderzoeken), voornamelijk de lijndiensten (ferry’s). Reders moet zeker zijn van de beschikbaarheid van LNG als brandstof.

Actoren/strategie

Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?
De havens m.b.t. LNG bunkering: waar positioneren we de faciliteiten? Ship- to- ship transfer?
Geld is op bij de overheid: weinig stimulerend in Nederland. Voor de scheepsbouw zijn er subsidies, echter laten de reders de schepen niet in Nederland bouwen.
Veel zal afhangen van de IGF code.
Ook de samenwerkingsverband tussen Wartsila en Shell laat zien dat nieuwe allianties een rol kunnen spelen in de toekomst.

Welke allianties kan Rederijen vormen m.b.t. LNG in de scheepvaart?
Reders kijken er wel naar, maar komt vooralsnog moeilijk van de grond.

Hoe zien de rederijen de eigen positie in een mogelijk toekomstig LNG markt?
Lastig opgave aangezien ze aan de milieueisen moeten voldoen. Economische mindere omstandigheden. Daarnaast zijn er geen concrete vergelijkingsmodellen tussen de verschillende brandstof alternatieven. Afwachtende houding
Op welke factoren denkt koepelorganisatie xte kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van koepelorganisatie x in de keten?

Betrokken blijven aangaande eisen die nu worden ontwikkeld. Lobbyen zodoende de belangen van de reders worden behartigd. De wens vanuit de reders is dat de wetgeving 5 jaar wordt uitgesteld.

Trends

In welke markten zal LNG een kansrijke toegang hebben?

Markten waarde zekerheid van levering LNG kan worden gegarandeerd. Verlagen van de risico’s zullen een push zijn in de markt.

Hoe ziet koepelorganisatie x en de rederiën de markt voor de komende 10 jaar?

- Reders willen zekerheid m.b.t. de technologie. Hierdoor willen ze dat wetgeving wordt uitgesteld. Dit zal voor de reders zorgen dat HFO en LNG als brandstof zich meer hebben bewezen, waardoor de keuze robuuster zal zijn.

- Bijzonder moeilijk om investeringen vanuit de bank te financieren in deze tijden.

Technology heeft zich bewezen. Maar de toepasbaarheid en wetgeving nog niet. Samenwerkingen zullen toenemen.

Veel hangt ook af van de IGF code.

- Meest realistische: dualfuel motoren> makkelijk kunnen overschakelen van gas naar diesel. Dit zal aantrekkelijk blijven totdat de onzekerheid is weggenomen.

Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?

Prijsverschil tussen LNG en de andere brandstoffen. Dit verschil moet groot genoeg willen zijn wil dit alternatief aantrekkelijk blijven.

Welke rol kan Royal Haskoning betekenen in de markt?

Mogelijk ontwerpen van bunkerfaciliteiten in de havens.
Appendix 9 Interview Bunkering Operator B

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Algemeen

- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?

Directeur

- Wat zijn de doelen van bedrijf b m.b.t. LNG en waarom?
  - Investeren in LNG bunker infrastructuur

Positie bedrijf b en technologische toepassingen

- Gezien de huidige supply chain van LNG, waar zou u positie in de waarde keten als bedrijf nu willen innemen?
  - Productie>liquefaction>shipping>terminal>distribution>end-user?
    Distributie: leveren van LNG aan eindgebruikers. Mogelijk later ook opslag
  - Waar in de toekomst?
    Andere bunker faciliteiten op andere locaties

- Wat zullen de enabelers zijn voor bedrijf A om te investeren in LNG toepassingen, zoals opslagtanks, bunkeringfaciliteiten?
  - Betrouwbaarheid technologie? Technologie is aanwezig, geen belemmering.
  - Kosten? Financiële randvoorwaarden vormen geen obstakel.
  - Prijs LNG? Techniek voor gebruik van LNG is belangrijk. Economisch gezien is het goedkoper om LNG te gebruiken dan scrubbers

- Welke factoren belemmeren bedrijf A om te investeren in LNG op dit moment?
  - Technische barrières: opties voor bunkering, opslag en transport?
  - Infrastructuur? Sunk kosten?
  - Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  - Beleid: wat is verwacht beleid van overheid in de scheepvaart?

  Barrière is dat er op dit moment geen vraag is in de markt. Daarop kunnen wij niet bepalen hoeveel LNG importeren. Daarnaast werken we samen met een rederij om deze barrière weg te nemen.

- Wat zijn mogelijke oplossingen om barrières weg te nemen?
Samenwerken met andere partijen in de markt.

- **Kan bedrijf b een rol spelen bij het mogelijk maken van LNG als brandstof voor de scheepvaart?**
  - Zo ja, in wat voor opzichte?
    Leveren van LNG aan de schepen: Opzetten van infrastructuur voor bunkeren.
- **Hoe wordt de positie van andere betrokkenen m.b.t LNG in de scheepvaart industrie gezien?**
  Partijen dienen de economische voordelen in te zien. LNG moet niet benaderd worden vanuit een milieu vriendelijk gedachtegoed.

**Actoren/strategie**

- **Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?**
  De overheid kan een belangrijke rol spelen d.m.v. subsidies aan rederijen of partijen die infrastructuur realiseren.
- **Welke allianties kan bedrijf B vormen m.b.t. LNG in de scheepvaart?**
  - Welke samenwerkingsverbanden zijn al gevormd?
    - Samenwerken met rederij Deen shipping
    - Samenwerken met Holland innovation team
  - **Toekomst?**
    - Partnerschap vraag in markt te doen toenemen.
- **Hoe ziet bedrijf b de eigen positie in een mogelijk toekomstige LNG markt?**
  - **Wie zijn de klanten?**
    Eindgebruikers van LNG: scheepvaart wordt op dit moment gezien als de markt waar de vraag de komende jaren zal ontstaan en zal toenemen. Bedrijf b wil op deze vraag vanuit de scheepvaart inspelen d.m.v. bunkerfaciliteiten.
  - **Op welke factoren (kosten infra, bunkering, motoren) denkt bedrijf B te kunnen beïnvloeden op korte termijn? Waar ligt de toegevoegde waarde van bedrijf B in de keten?**
    - Realiseren van bunkerfaciliteiten voor de scheepvaart zal door bedrijf B een toegevoegde activiteit zijn in de waardeketen.
    - Goedkoop leveren LNG t.o.v. andere brandstoffen
- **Trends**
  - **In welke markten zal LNG een kansrijke toegang hebben? (scheepvaart, vrachtwagens, energy supply Nederland)**
    Bedrijf B zal zich de komende jaren eerst focussen tot de scheepvaart: voornamelijk binnenvaart. Ook de kustvaart biedt veel kansen door komst van SECA gebieden.
• **Hoe ziet bedrijf B de markt voor de komende 10 jaar?**

Verwachting is dat LNG een belangrijke rol zal spelen als fuel brandstof voor de scheepvaart. Wanneer vertrouwd wordt geraakt met de technologie, zullen LNG toepassen zich uitbreiden. De vraag in de markt zal toenemen, waarna LNG zich zal nestelen als een vertrouwd brandstof in de industrie. Hiervoor dienen echter wel voldoende bunkerfaciliteiten gerealiseerd te worden in Europa.

• **Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?**

De prijsverhouding van LNG t.o.v. andere brandstof alternatieven. Mits LNG goedkoper is dan scrubber technologie en de prijs in de toekomst zoals verwacht lager zal zijn dan HFO, dan zal LNG een serieuze rol spelen in de markt.
Appendix 10 Interview Royal Haskoning

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- Wat is uw functie binnen het bedrijf en wat is de betrokkenheid met LNG?
  Senior Consultant Advisory Group Oil & Gas

- Wat zijn de doelen van RH m.b.t. LNG en waarom?

Een toegevoegde speler in de markt.

- Gezien de huidige supply chain van LNG, waar zou u positie als bedrijf nu willen innemen?
  o Waar in de toekomst?

  Dienstverlenende taken m.b.t. veiligheid en milieu.

- Wat zullen de enablerers zijn voor RH om te investeren in LNG toepassingen, zoals opslagtanks, bunkeringfaciliteiten?
  o Betrouwbaarheid technologie?
  o Kosten?
  o Efficiency van LNG?
  o Flexibiliteit?
  o Veiligheid kwesties?
  o Compatibility, simplicity, try-out, context, advantage?

  Kennis vanuit andere sectoren binnen bedrijf. Immers RH kan terminals ontwerpen voor bulk overslag. Ook is er ruime expertise m.b.t. het in kaart brengen van risico contouren van verschillende projecten.

- Wat kan gezien worden als barrières voor LNG in de scheepvaart?
  o Kosten?
  o Technische barrières: opties voor bunkering, opslag en transport?
  o Infrastructuur? Sunk kosten?
  o Gebruikers voorkeuren? Hoe denken de rederijen en havens hierover?
  o Beleid: wat is verwacht beleid van overheid in de scheepvaart?

  We zijn geen main contractors, dus kunnen niet bouwen. Ook is er binnen bedrijf niet evenveel kennis m.b.t. LNG als bij bijvoorbeeld Tractebel.

- Welke factoren belemmeren RH om te investeren in LNG op dit moment?
  o Mocht op een later stadia geïnvesteerd kunnen worden: waarom niet nu en later wel?

  Machtpositie in de markt voornamelijk hekelpunt. En ook niet de expertise m.b.t. LNG.
o Kan RH een rol spelen bij het mogelijk maken van LNG als brandstof voor de scheepvaart?
  o Zoja, in wat voor opzicht?

Betrokken raken bij veiligheidsstudies/milieustudies bij realisatie van bunkerfaciliteiten voor LNG schepen.

- Hoe wordt de positie van andere betrokkenen m.b.t. LNG in de scheepvaart industrie gezien?
  o Wie zijn de voortrekkers in de markt?
  o Waar ligt de macht in de markt?

Tractebel is een sterke speler aangezien zijn 1 van de 3 spelers zijn de expertise hebben om daadwerkelijk LNG terminals te bouwen. Zij zijn in bezit van een groot energiebedrijf uit Frankrijk (Suez).

- Welke actoren spelen op dit moment geen rol, maar zullen in een later stadium een belangrijk positie in de markt nemen?

- Welke allianties kan RH vormen m.b.t. LNG in de scheepvaart?
  o Welke samenwerkingsverbanden zijn al gevormd?
  .Partnerschap met bedrijven die veiligheid en milieu zaken goed geregeld willen hebben

- Hoe zien partijen de eigen positie in een mogelij toekomstige LNG markt?
  o Met wie werken ze samen?
  o Wie zijn de concurrenten?
  o Wie zijn de klanten?

- Hoe ziet u de markt voor de komende 10 jaar?

RH kan een toegevoegde waarde hebben m.b.t. veiligheid en milieu. Ook zal de kennis toenemen voor de design van LNG terminals.

- Welke trends zullen doorslaggevend zijn bij het succes of falen van LNG in de scheepvaart als brandstof?
Interview Royal Haskoning

Functie?

Business Developer

Hoe worden nieuwe opdrachten bij RH binnengehaald?

Vaste relatie onderhouden met klanten. Relaties binnen eigen netwerk zijn erg belangrijk. Nieuwe acquisities komen hieruit voort. Een ander aanpak is om conferenties te bezoeken, mensen te spreken en te borrelen om in contact te komen met potentiële werkgevers.

Hoe wordt omgegaan met innovatie binnen RH?

Innovatie is binnen RH een proces. Opdrachten die we voor de klanten uitvoeren zijn innovatief en samen met de klant brengen we innovatie tot stand. Innovatie wordt daarmee dus door de klant betaald.

Is er geen eigen budget voor innovatie?

Jawel, maar dit potje is heel klein. Samenwerken met andere partijen is een optie om dit te overbruggen. Maar voornamelijk, als een idee interessant is, proberen we dit te koppelen aan onze klanten. Immers wij zijn er om de ambities van onze klanten te verwezenlijken. Verstandig is om kleinschalig te opereren en ideeën te koppelen aan een launching customer. Innovatie neemt risico’s met zich mee en door deze aanpak verminderen of verspreiden we de risico’s.

Hoe wordt een nieuwe markt betreden, bijvoorbeeld Japan?

Samen met een klant werken aan 1 project. Klein beginnen. Deze projecten dienen om de markt te betreden. Vanuit hier volgen er nieuwe projecten, waarna we echt kunnen settelen. In verloop van tijd kan er een strategisch partnership worden gevormd met de klant.

Samenvattend om LNG als uitval nemend: Hoe kan RH de markt benaderen?

- Klant zoeken die innovatie kan financieren. RH heeft de expertise en vertrouwen in de markt om nieuwe ambities van klanten te bewerkstelligen
- Expertise binnen bedrijf vergroten. RH staat bekend om zijn professionals en wil RH zich profileren als LNG goeroe, dan moet er ook genoeg kennis binnen het bedrijf aanwezig zijn.
Appendix 12 Flevum Conference

Minutes

Present: Emrukala Metin, Arjen van Bruchem
Absent: 
Date: 12-10-2011
Copy: Berte Simons, Geoffrey Bothamley, Erik Huber, Mike Ramsey, Bart vander Velpen, Brad Froyland, Andrew Penfold, Harel van den Brink

Our reference: Minutes Flevum network meeting LNG Rotterdam 12-10-2011.doc

Subject: Future of LNG in Rotterdam

Minutes of Flevum network meeting 12 October 2011 at Argos, Rotterdam. Four presentations are held with a social meeting afterwards.

1 ARGOS OIL – PIET VAN DEN OUDEN
Argos – NSG consider themselves as logistic service suppliers in energy. They have three focus areas:
• Oil (mature)
• Gas (child)
• Electrical (baby)
Three reasons why LNG is important for Argos
• Price gas: gas price is connected to oil price, but because of the APX gas market in NW Europe, the gas price will increase less than oil price. The difference between oil price and gas price is something which Argos want to use for business;
• Availability of gas: enough gas and technology is far enough to apply;
• Next to ships on LNG, terminal tractors are the next group of low hanging fruit for LNG. In America, Longbeech, this is already applied. The SES Terminal in Long Beach (Conoco Phillips & Mitsubishi) is an important example for Argos (see attached PPT which I found on the web).

Argos wishes to cooperate with other stakeholders and wants to invest. But, till now investments are delayed because of uncertainty around legislation, standardization, safety regulations and harmonization permits. As example a standardized LNG fueling station.
Planning Argos:
• Concept project plan: dec/jan
• Pilot project: mid February 2012
• Implementation plans: 2012 – 2014
End of year a study trip to Long Beach, USA.

2 BALLAST NEDAM – BAS HOLLEMANS
Ballast positions themselves in the LNG market in the whole chain; from financier till exploitation of gas stations. They have already invested in the infrastructure for CNG (Compressed Natural Gas). In NL 45 of the 70 natural gas gas stations are Ballast Nedam. For CNG they use the gas network and compress it to 200 bars.
Trucks and cars are already delivered on dual fuel;
They see possibilities for shipping, trucks and trains
Ballast Nedam focuses on building complete LNG gas stations. There are 13 stations
planned. They implementation is on HOLD now because of legislation / standardization for filling stations.
Ballast wants Argos to exploit LNG filling stations. They already import LNG from Zeel布鲁格; the GATE terminal does not support truck / barge delivery yet.

3 TNO – BAS VAN DEN BEEMDT (business development oil&gas)
Ambition of TNO is to take away barriers for innovation, which requires an active and open approach of all stakeholders. They advocate the approach of first starting with LNG on small scale. Then you stumble on several problems (legislation / safety / environmental) and then legislation has to be adapted / made.
The price of a LNG drive (motor + tank) is twice that of a diesel drive (motor + tank). Gate terminal has plans to do truck loading also. Fluxys in Zeel布鲁格 has already truck loading (see http://www.fluxys.com/nl-BE/Services/LNGTerminating/TruckLoading/TruckLoading.aspx).
TNO is leading in the Legislation & Safety study for LNG in Rotterdam (LESAS project). The objective is to prepare an advice for authorities; method is a safety assessment. Technological challenges:
• Hoses for small scale LNG handling might be a problem, but here we have to learn from the big scale LNG;
• Safety aspects of ship-to-ship bunkering;
• Onboard storage of LNG: development new enclosures;
• Motor performance: efficiency and emissions;
• For truck filling there is already a PGS commission active;
• LNG Container transport is also a possibility (already applied in America). Not advised by TNO because of all empty containers circulating → safety problem. Liquefaction of natural gas from the grid is not a good idea according TNO, because of the value natural gas already has in the Netherlands. It does not add value. In contrast with the gas imported from (i.e.) Qatar, where the gas is very cheap and the liquefaction and transportation adds value.

4 PoR – Wilco van der Lans
Chances for LNG in Rotterdam:
• Potential to grow to the 3th bunker market;
• Development of breakbulk LNG terminal;
• Realization of bunkering station for inland shipping and trucks.
Problems:
• Quality gas is not constant;
• Composition gas can change over time;
• A lot of ignorance; a lot of communication required;
• Legislation is not yet available, which disable the sailing on LNG.
Nobel in Zwijndrecht is a pioneer with the realization of the first LNG bunkering facility. See http://www.prcfnews.nl/969203/zwijndrecht-krijgt-eerste-lng-bunkerstation.

5 People
Michel Oosterberg – Cummins Holland
Cummins produces engines for trucks and ships. They see opportunities to make LNG driven engines. They are however slightly pessimistic. Without demand in the market, they are reserved in investing in new technology. This confirms the situation of who is taking the first step’.
Dolf Bierhuizen – Automotive centre of expertise
Dolf has founded a taskforce with 3 HTS colleges. They cooperate in preparing new vehicle drives, such as electric drive, bio fuel and LNG. He expects that in some sectors vehicles will move to LNG in the near future.
Laure Couvet, Marijolle van de Boogerd – Kneppelhout & Korthals advocaten
As lawyers they want to know their clients better and want to know their playing field, which explains their presence.
Appendix 13 Conference Small Scale LNG organized by IIR

A short summary of the findings during the conference will be given.

(Due the confidential rules of the IIR organization, presentations of the firms could not be added in this research. These can be shared on demand.)

Market players

Lots of market players like: TNO, Argos, Linde Gas Group, Shell, Vopak, Gasunie, Rolls-Royce had given a presentation. Also representatives of other organizations gave their views about LNG, like: ISO and RIVM. It was remarkable that no shipping company or representatives of the Dutch ports where present at the conference.

Another remarkable point was that many market players where present which presented their ideas regarding the use of LNG for trucks. Rolande B.V and Vanetti are two firms who want to realize fuelling stations for LNG trucks in the near future. The presence of Spanish and Italian firms showed that LNG is also interesting for businesses in their country, hence the regulations regarding sulphur and NO\textsubscript{x} could be introduced in the Mediterranean Sea.

Messages

Most of the parties showed the enablers and barriers for the use of LNG in their businesses. The main barrier for the use of LNG as marine fuel will be the availability of bunkering infrastructure all over Europe and the uncertainty regarding the LNG price in the future. For now, Norway is the country which has been used as an example how the market for LNG in the shipping industry could be introduced. The main difference between Norway and the Netherlands is the fact that the Norwegian government stimulates the market to invest in LNG, where the Dutch government does not have a similar policy.

Another message what was given is that LNG as fuel for trucks will be realized sooner than LNG as marine fuel for vessels in the Netherlands. The developments are far further and Rolande BV and Ballast Nedam are currently working for filling stations. Potential clients to use these stations like food distributors where active and announced that they expect to use LNG trucks in the coming years.

Another interesting point was that two big engine producers where presenting their new engines which were capable of using LNG. Rolls-Royce and Wartsila will be in a battle to win a big market share in delivering LNG engines for shipping companies in the future.

Concluding remarks

It can be concluded that LNG is an interesting energy source to be exploited in different market segments, like shipping industry as marine fuel and as fuel for trucks. Market players are trying to develop profitable businesses to use LNG, but at the current time there are barriers to overcome. The expectations are that in the coming 5 years many barriers will be tackled and the market players will get trusted with LNG technology. For now market players are trying to explore which partners could assist them to realize new businesses. The market is in an exploring mode and for now looking for the right moment to invest or to cooperate with other firms.
Appendix 14 Article

The introduction of LNG as marine fuel in the Dutch Shipping industry: Is LNG really hot or not?

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ABSTRACT

Many countries struggle with the emission pollution regulations for sea-going ships which the European Union has set up. To analyze the positioning of market players in the Dutch sea-shipping industry and how they see the use of Liquid Natural Gas (LNG) as marine fuel to meet the pollution regulation, a literature review and in-depth interviews among market players were carried out. The results show that the market players are far more pessimistic about the potential of LNG as marine fuel compared to what the literature shows us. To reduce the uncertainties in the market, especially more cooperation between the involved actors seems necessary. To make this cooperation feasible and to develop new business models for market players, further research will be needed.

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1. Introduction

Developments in the shipment industry show that there is a possibility in which the industry will embrace LNG vessels in the future. The EU has announced to adapt the emissions allowed on the ECA (Emission Control Areas) by 2015. (Magalog Project, 2008). The current shipping vessels will not fulfill the sulphur dioxide (SO\(_2\)) and nitrogen oxides (NO\(_x\)) emission restrictions, which will lead to an adaptation of the vessels by the shipping companies (Bengtsson, Andersson, & Fridell, 2011). Involved actors, like shipping companies, gas companies, ports and engine companies see opportunities to invest in Liquid Natural Gas.

Other alternatives to meet the emission standards can be achieved by using low- sulphur Marine Gasoil (MGO) or installing exhaust scrubbers on Heavy Fuel Oil (HFO) (Alvestad, 2011). MGO does not require extra volume for storage as for LNG and retrofitting of the engine is not required. The investment costs will therefore be minimal (Levander, 2011). HFO will also fulfill the requirements in SECA 2015 and the TIER 3 standards. Further stricter emission standards will require scrubbers for SO\(_2\) and particulate matter (PM) removal. This will lead to more capital investments as to more produced wastes by the scrubbers (TEN-T, 2011). The ports are not pro HFO bunkering because of the environmental risk regarding the handling. Currently there are no guidelines for Ports to handle the waste. Here it can be mentioned that the conventional fuels require less adaptation of the fuel and engines, but require additional services and places where reduction in sulphur and NOx can be realized. On the other hand, LNG requires new engines and more storage place in the vessels for fuels and new infrastructure for the accessibility of vessels.

Currently, the technology for LNG is mature enough to explore the possibilities in this industry, but at the moment there is no infrastructure in the Netherlands to refuel LNG ships. There are firms that are converting their vessels to use LNG instead on oil. Involved actors are cautious to invest and bear the risks that come with this new and innovative system. The problem is that if there is no infrastructure for LNG vessels so no investments will be conducted to build LNG vessels by shipping companies. On the other hand: if there are no ships which will demand LNG as fuel, there will not be an infrastructure needed in the Netherlands. Another important aspect is that the safety regulations regarding LNG are not available. For now, actors don’t have the knowledge or information which probably will constrain their investments in this market.

Despite the risks and uncertainties, different market players in the Netherlands are nowadays looking for business opportunities in the new developing LNG market in Europe. The available literature show that LNG as marine fuel will be very attractive in the future. LNG is launched as the substitute of the current marine fuels and many conferences are now organized to send this message into the world. However, does LNG as marine fuel really have the
potential in the shipping industry? This paper will present the information gathered from experts interviews in the Dutch shipping industry, who are currently involved with LNG related businesses. Research has been conducted to give insight how market players are positioned in the shipping industry. The interdependencies between the market players, their goals and interest and their expectations regarding the use of LNG as marine fuel will be shown.

Section 2 will present the methodology used to gather data. Not all market players could be approached, because not all were prepared to participate in this research. Section 3 will present the results of the interviews and will present the relations between the market players and the critical actors in the Dutch shipping industry. Section 4 will show the expectations of market players in the future. Finally conclusions and recommendations for further research will be given.

2. Methodology
Firstly the literature has been used to map the important market players in the shipping industry. The relations between the actors has been analyzed and their possible role in the future. Formal diagrams and the concepts of Dynamic Actor Network Analysis (Bots, 2008) has therefore been used. To gain knowledge about the relations between the market players, their goals and interest and their future expectations regarding LNG as marine fuel, interviews has been held at different experts in the industry. These interviews are held to compare the expectations regarding LNG from the real world with what has been written in the literature. These interviews are not used to test hypotheses, but they serve to get a feeling of the current developments in the Dutch shipping industry. The experts who have participated on this research are presented in the table 1.

3. Positioning of actors in the Dutch shipping market
A network diagram is a helpful tool to map the relations between the actors and to show how the relations and dependencies are at the current situation. This diagram (figure 1) will give a presentation of the current situation and is just a snapshot. The relations and dependencies can differ when looking at the market after for example two years. This section will present the interdependencies of actors in the system and show how they relate to each other in the LNG system (introduction of LNG as marine fuel in the shipping industry will be mentioned as ‘LNG system’)

3.1 Interdependencies between market players
The EU and the IMO have decided to implement new regulations with emission restriction for the ECA region in the EU. IMO expects that the new rules regarding sulphur and NOx emission will be internationally accepted in 2020. The EU members and the Dutch government will have to follow these EU guidelines and will have to adapt their national regulation to the requirements. This will have consequences on for example the ADNR (Accord Européen relatif au Transport International des Marchandises Dangereuses par voie de Navigation du Rhin), which now prohibits using LNG as fuel for inland shipping. The regulations can be seen as one of the triggers making the actors in the system think about how they can adapt to the new rules in the game. An international rule is now seen as the starting point of a possible transition from oil to gas using vessels.

Three alternative marine fuels are available providing solutions for the shipping companies. These firms are an important stone in the whole LNG chain and the system. Hence, their decisions will make it clear in the end which alternative marine fuel will be used the most. It is not said that one fuel alternative will be used by all the shipping companies. Interviewee of the ship-owner association mentioned: the ratio between oil and diesel in the automotive industry can also be the case in the shipping industry. Looking at table 1 it can be seen that the shipping companies depend on shipbuilders and Ports in the Netherlands and in Europe. The shipbuilders will provide new solutions for shipping companies in which they can execute their shipping activities at a lower cost than in the current situation. A new ship design is required to make competitive vessels using LNG as fuel. Here the tanks and new additional systems are required to achieve this. Shipyards have to think about these new requirements and find cost effective solutions for their customers. In this case it is obvious that shipping companies depend on the innovation power of ship builders. Interviewee of the shipbuilder noticed that engine companies and component suppliers were not transparent enough about their products and deliver products for high prices. This was one of the reasons why a LNG vessels cost more than a conventional ship. Also converting current vessels has been mentioned as a solution, but here high costs for shipping companies are involved. The shipping companies will be driven by the fuel option which will cost them the least. Interviewee of the ship-owner association and the bunkering operator B made an important point in which they conclude that the current ships in the Netherlands are new, so for them it would be very costly to buy new LNG vessels for their business. The converting cost to LNG will be more interesting for Dutch shippers than the investments required for a
new ship. However to finance this became hard during economic drawbacks in the Netherlands and EU.

Figure 1 - Presentations of relations between market players

The shipbuilders like Damen shipyards are in this system depended on engine companies and suppliers of other additional components. The building cost of a LNG ship will heavily depend on the price of the engine and the tanks required for LNG storage. It is obvious that the engine producers will compete on delivering the most efficient and powerful engines to shipbuilders. Now, Wartsila and Roll-Royce have engines which allow using LNG as fuel. If these companies are able to deliver proper engines to shipbuilders at a lower cost compared to conventional engines (which now is not the case), the shipbuilders can deliver attractive LNG ships for shipping companies. The relations between these three actors are very narrow and it will be interesting which engine (dual fuel or lean gas) will capture the market for new LNG vessels. Therefore, engine producers are now very active to promote their engines in the market and try to make alliances with other companies. Another important actor according to interviewee of the shipbuilder will be the classification companies who certify these new ships or ships which will be converted. Hence new ship designs and engines are required, these types of companies will certify the new ships and therefore practice a certain power in the market. The shipbuilders and shipping companies will depend on the standards of these companies. Contrary to this view the interviewee of the ship-owner association said that the IGF code from IMO will be the guide line for the industry regarding standards, but not the standards from certifying companies. DNV is one of them who has penetrated the market and uses their strategic position in different directions. They certify many ships in Norway and have put standards in the industry which mainly are used in Norway. By using their experience and position as a certification organization, they try to put their standards as international guidelines for ships on LNG.

Beside the costs of a LNG vessel for shipping companies, the infrastructure will be another trigger for a successful introduction of LNG as marine fuel. Now there are no bunkering facilities in the Netherlands realized. A Nobel Zn has announced to provide bunkering activities of LNG for ships in December of 2011 (NNo). If no LNG is available for shipping companies, they will not even think to convert or buy new LNG vessels. They heavily depend on actors who can provide them LNG. The first LNG terminal has been realized by VOPAK and Gasunie. At the conference organized by Argos an expert from Ballast Nedam complained about the fact that there is no possibility to get LNG in smaller proportion from the Port of Rotterdam (Flevum, 2011). In the meanwhile Gasunie and Vopak have announced that in 2015 bunkering services to ships and trucks will be provided (Schuttevaer, 2012). This terminal is built to import LNG for the national gas grid of the Netherlands. Hereby an independent gas supply from Russia can be arranged if needed. The availability of LNG in the system depends on the import of LNG by the Gate Terminal, because the LNG can only be imported at this terminal. Another nearest LNG terminal is located in Zeebrugge. Shortly it can be mentioned that Gasunie and Vopak have an important role in the value chain, but this is not only based on the availability of LNG. Also the price of LNG will depend on the volume of LNG imported and the quality of the gas. In the interview with Nobel and Bas van de Beemt they mentioned that the price of LNG will be determined at the spot market, but Vopak and the Gasunie will obviously be able to influence the price. If the demand increase for LNG in the market, it will become cheaper to buy LNG from the gate terminal.

The current firms in the oil related industry see opportunities in providing bunkering services regarding LNG. Argos is one of them who want to provide bunkering facilities for their customers in the industry. They have for the coming years (2012-2014)
plans to realize LNG bunkering pantons and from 2016 they will be able to realize ship to ship bunkering of LNG (BunkeringOperator_A, business development manager, 2011). Therefore they need standards and permission for these kind of activities. The requirements for ship to ship bunkering are not internationally defined and also on a national level standards and requirements are missing. Argos heavily depends on the development of the guidelines and also on the Ports which gives permits to conduct bunkering activities. To be operational in the coming years, the interviewee of the bunkering operator A said that the company cooperates with TNO and the Port to develop the required standards (LESAS project).

3.2 Critical market players
The EU and the IMO have announced the emission restrictions in 2015 and the goals related to 2020. The EU has great economic and political power. For now, the EU has restricted the shipping industry and set up an institutional constrain upon the system. Their main resources has been the given guidelines and regulations. They set up the new rules of the games and other actors will play their games within their roles. Besides their institutional power, they are able to give subsidies to other actors.

Table 1 – Critical actors in the market

<table>
<thead>
<tr>
<th>Critical actors according the interviewees</th>
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<tbody>
<tr>
<td>Bunkering operator A</td>
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<td>Ship-owner association</td>
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<tr>
<td>Research institute</td>
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<tr>
<td>Shipbuilder</td>
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<td>Engine producer</td>
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<tr>
<td>Knowledge institute</td>
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<tr>
<td>Bunkering operator B</td>
</tr>
<tr>
<td>Gas transporter</td>
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<tr>
<td>Umbrella Organization</td>
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<td>Ports</td>
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Actors could undergo positive or negative effects of the subsidiaries. If the EU government strengthens the rules related to emission of sulphur and NOx in which only LNG will fulfill the requirements, actors using HFO with scrubbers and MDO will have real problems. The EU is a critical actor but has a temporary political mandate. On short term the EU parliament could not be substituted except at the time of elections. The IMO is also an important critical actor in the system. They work on international treaties and safety standards for the marine industry. Also they work on legislation to prevent marine pollution. Their main resource is to adopt legislation. They keep legislation up to date and ensure that is ratified by as many countries as possible. This excludes the authority to enforce legislation and to act like the police. This shows that contrary to the EU this organization cannot change the rules of the game, but only refine or make recommendations (IMO, 2011).

The Dutch government can play a significant role also in this system. Not on regulatory base, hence this is arranged internationally. The government can provide additional subsidiaries for actors willing to invest in emission free marine fuels. Also they can provide adjustment to national rules that can allow private markets operate without different kind of barriers. This actor will continuously change during time hence new elections could allow other ideas entering the Dutch parliament. This could have effects on the overall perspective related to subsidiaries in the shipping industry. In contrast with the government, the Ports don’t have regulatory or economic powers. They can only provide the right circumstances for private organizations investing in bunkering facilities for LNG. In the system this actor is important because the infrastructure for LNG is not available right now. The Ports have the power to realize this with private companies.

Looking to the private companies in the system, they possess other powers in the system. Rolls Royce and Wartsila have the technology to make LNG engines cheaper, emission free and powerful compared to other engines. The shipyards are similar actors in the system with technological power. According to the interviewee of the ship-owner association and the shipbuilder the role of these firms in the system will influence the strategies of shipping companies. These big companies can be substituted by other market parties who will be able to deliver better engines in the market or deliver better ships. For now they are the one with expertise and developed knowledge based on gas engines. Contrary to this vision, the interviewee of the bunkering operator A mentioned that the technology already is mature enough, but the missing of the infrastructure for LNG vessels still remains as an important barrier for shippers to invest in LNG vessels.

The shipping companies are the one with the most important critical power in the system: this actor will decide which marine fuel they will use in the future. The circumstances and the constrained are set up by other market players, but they will in the end make a decision. The shipping industry can be divided in different segments, like: inland, short sea, ferry, cargo
and so on. Shippers in these segments will have different conditions for making their own choices. Based upon their decision the market will go in that direction. This power gives them a critical position in the system.

The oil related firms who focus now on bunkering facilities for LNG will take also a critical position in the market. They give solution to one part in the chicken and egg problem of the system, namely: enabling infrastructure for vessels. Their power is having the knowledge in bunkering operations, but still this power is constrained by new requirements of standards for LNG. Also they have already an important position in the oil industry, so enough economic resources to invest in new markets.

4. Future expectations of market players

Beside the interest and goals, the criticality of the actors and their interdependencies, also further expectations regarding important trends are asked to interviewees.

Table 2 shows that the main important trend will be the development of the LNG price. Next to price developments others think the development of legislation will have an important effect on the system. Also remarkable is the fact that no one has mentioned alliances between actors as a possible important development in the future. The literature showed also that the price of LNG and legislation will be important and similar conclusion can be made about the gained information from the interviews (Jensen, 2004).

Finally the expectation of the experts has been asked which marine fuel they think it will be used to fulfill the new emission regulations in the ECA region.

Many give LNG and HFO with scrubbers a good chance in the future which will be used as marine fuel in the Netherlands. For them it’s also uncertain which alternative will be the favorite. The interviewee of the ship-owner association which represents the shipping companies in the Netherlands says diesel will be used despite the high fuel cost of diesel. The main reason for this will be the fact that the market is very uncertain and unreliable for the shipping companies.

Table 3 - Expectations interviewees regarding future marine fuel

<table>
<thead>
<tr>
<th>Important Trends</th>
<th>HFO SCR</th>
<th>MDO/MGO</th>
<th>LNG</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunkering operator A</td>
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<tr>
<td>Ship-owner association</td>
<td>x</td>
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<tr>
<td>Research institute</td>
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<tr>
<td>Shipbuilder</td>
<td>x</td>
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<tr>
<td>Engineering firm</td>
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<td>Engine producer</td>
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<td>Knowledge institute</td>
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<td>Umbrella organization</td>
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<td>Ports</td>
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<tr>
<td>Conference Amsterdam</td>
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<tr>
<td>Wartsila</td>
<td>x</td>
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<tr>
<td>Bunkering operator B</td>
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</table>

Therefore they will choose for the most trustable fuel option. The information gained from the literature show that LNG will from an economic perspective the most attractive option to fulfill the new emission requirements. The experts, on contrary, have divided opinions in which scrubber technology and dual fuel application have also a good potential in the market. These expectations are not only from an economic perspective, but taking also other factors in the system into account. Another important point which can be made is that firms providing SCR technology do not lobby as much as the LNG lobby in the market. The market players are more involved where LNG is tested, compared to HFO and MGO.
5. Conclusion
Lots of market players are involved in the LNG system. It can be concluded that they currently are in a wait and see position. The uncertainties regarding the price of LNG, the development of standards and legislation and the availability of bunkering facilities for LNG make the shipping companies hesitate to invest and choose for LNG as marine fuel. Because of the dependencies in the market also other actors are waiting to see what the developments will be on the short term. The literature showed that LNG has a great potential as marine fuel, but the experts are less optimistic, especially for the short term. It can be concluded that the new emission requirements in 2015 will not fully be satisfied by the use of LNG, but on the middle-long term LNG can fulfill the expectations as marine fuel.

6. Discussion
The use of LNG as marine fuel will remain a hot item in the short term for the market players in the Netherlands. Because of the complex system and the highly interrelated multi actors setting were the market players are involved, it will be hard for them to decide how they will adapt their business strategies in the future. Reducing the uncertainties in the future will help them to make better decision than at the current time. Cooperations between market players could reduce the uncertainties in the future and can help market players to take the risks investing in innovative systems.

The Dutch government can play a more active role in the market, by stimulating market players to invest in cleaner marine fuel technology. However the government must not forget to focus only on the reduction of emission in the shipping industry, and not only stimulating one marine fuel like LNG. Also the EU must be clearer on which EU seas in the future the emission rules regarding sulphur and NOx will be extended. For now these rules will only be implemented in the SECA region. Further research can be conducted to analyze how market players can cooperate together and can make attractive businesses out of the opportunities LNG as marine fuel provides. New business models can be developed to assist the market players in the industry.

This paper only analyzed the current positioning of market players regarding the use of LNG as marine fuel. The interviewees also noticed that LNG will be attractive in other businesses, like the use of LNG for heavy trucks. Therefore business opportunities for market players in other industries can be researched.


