Is LNG the fuel of the future for offshore support vessels operating in the North Sea?

Candidate name: Emily Jane Hough

Buskerud and Vestfold University College
Faculty of Technology and Maritime Sciences

MASTER THESIS

May, 2014

Abstract

The first PSV to run on LNG as fuel was delivered to the North Sea in 2003 the offshore sector has since taken delivery of 12 with 4 more to be delivered in 2014 and 2015. The environmental benefits of LNG gas includes reduction of NOx and CO2, as well as close to complete reduction of SOx and particulate matters from exhaust emissions. A Norwegian fiscal tax on NOx emissions prompted the establishment of the Business Sector's NOx fund that in exchange for a minimized tax on NOx, offered financial support to companies that implemented NOx reducing measures. For the Norwegian offshore sectore, this translated to a compensation of 80% of the additional costs relating to the building of an LNG fueled PSV compared to conventionally diesel driven. This qualitative study conducted semi-structured interviews with representatives from 4 different offshore companies currently operating with LNG fuelled PSVs to determine what the position towards LNG is today. The study showed offshore companies are no longer willing to build LNG vessels on a speculative basis. Incentive to build a LNG fueled vessel is now contingent on a long-term contract prior to building, where the charterer is willing to pay a premium as a result of higher building costs. The procurement method for newbuilding contracts of a major oil company operating on the Norwegian continental shelf is awarded on the basis of the technical and commercial superiority with no preference to fuel and is so the basis of which and LNG vessel could potentially be built.

Table of Contents

Acknowledgements

I would like to thank all the participants that took time out of their busy schedules in order to assist with the research of this paper. Along with my supervisor Erik W. Jakobsen, I especially want to express my gratitude to Tine Westerberg and Kjell Ivar Øvergård who gave me the motivation to complete this study.

Introduction

Questioning whether LNG is the fuel of the future for offshore support vessels operating in the North Sea seems like an redundant issue to examine, and one which has been discussed extensively in the past years. This is however a question, which still does not hold an answer, mainly due to constantly changing forces driving the advantages and weaknesses of operating LNG fuelled vessels. This paper will specifically focus on the North Sea region, the current commercial arena for the forerunners of LNG fuelled ships.

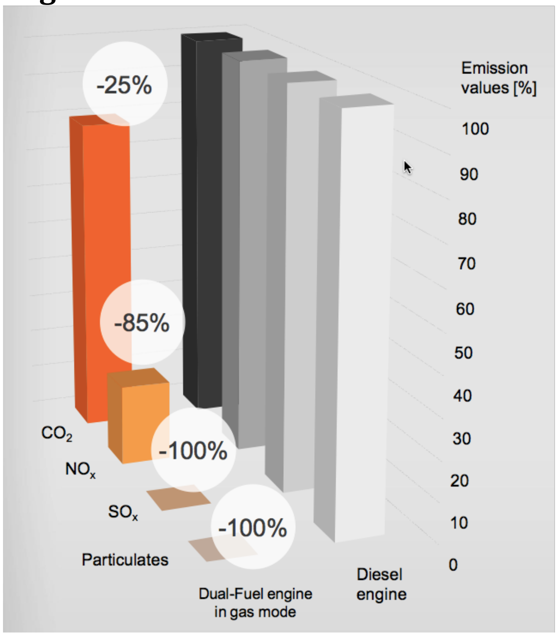
There are a multitude of arguments for and against the use of LNG as a fuel alternative in ships. In the North Sea, we are seeing PSVs operating with dual fuel engines allowing for the use of LNG and MGO with 4 more on order. This paper will firstly outline the current environment for LNG as a functioning marine fuel in the North Sea, and will further explore ship-owners experience with LNG vessels today as a basis for what it could mean for the future.

What is LNG?

Liquefied Natural Gas (LNG) consists predominantly of methane with small amounts of other hydrocarbons and is the liquid state of natural gas after it has been cooled down to -162 Celsius degrees. (Shell, 2014) By changing the state of natural gas to liquid, the volume of the liquid becomes 600 times smaller than that of its original gaseous state allowing the storage and transport of the gas. LNG as a fuel is considered a greener alternative than regular distillate fuels being used by offshore supply vessels in the North Sea. Emission reductions using LNG against Marine Gas Oil (MGO) are as follows (DNV, 2010b):

- Approx. 25% reduction of CO_2 emissions
- Approx. 85% reduction of NO_x emissions
- Almost 100% reduction of SO_x emissions
- Almost 100% reduction of particulates

Figure 1: Emissions from Dual-fuel engine in gas mode and conventional diesel engine.



(Wartsila, 2012)

Role of a PSV in Upstream Logistics

Upstream Logistics is defined as "supplying the offshore drilling and production units with the necessary supplies" (Aas B., Halskau Sr Ø., & Wallace S W, 2009) The PSV constitutes as a vital role for the upstream logistics with the function of transporting supplies on deck as well as bulk segregated into tanks that can carry different cargoes such as potable water, brine, liquid mud, methanol, etc. to and from the offshore unit. A PSV is typically grouped into three sizes; small, medium and large depending on the size of its deck. (RS Platou, 2014)

Due to the nature of a PSVs small size and capabilities, a charterer will hire the entire vessel and so they are only contracted on time charters. Being employed on term or spot basis will mean that in all instances, the charterer will be responsible for covering the fuel costs of the vessel when it is on hire.

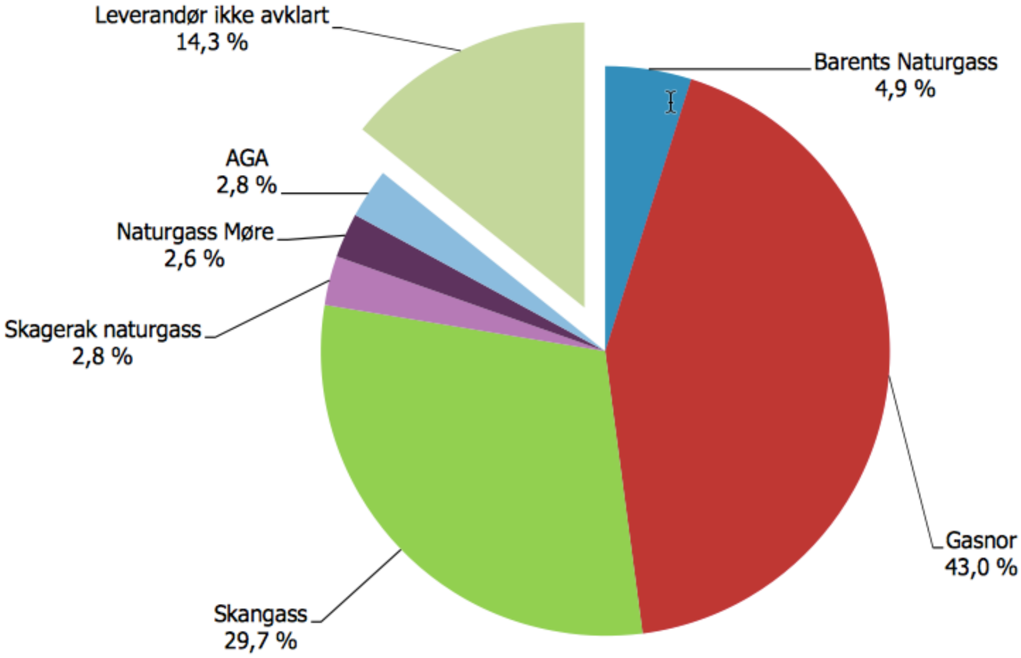
LNG Bunkering for North Sea operations

Figure 2: LNG Bunkering in Norway

Source: (DNV, 2014)

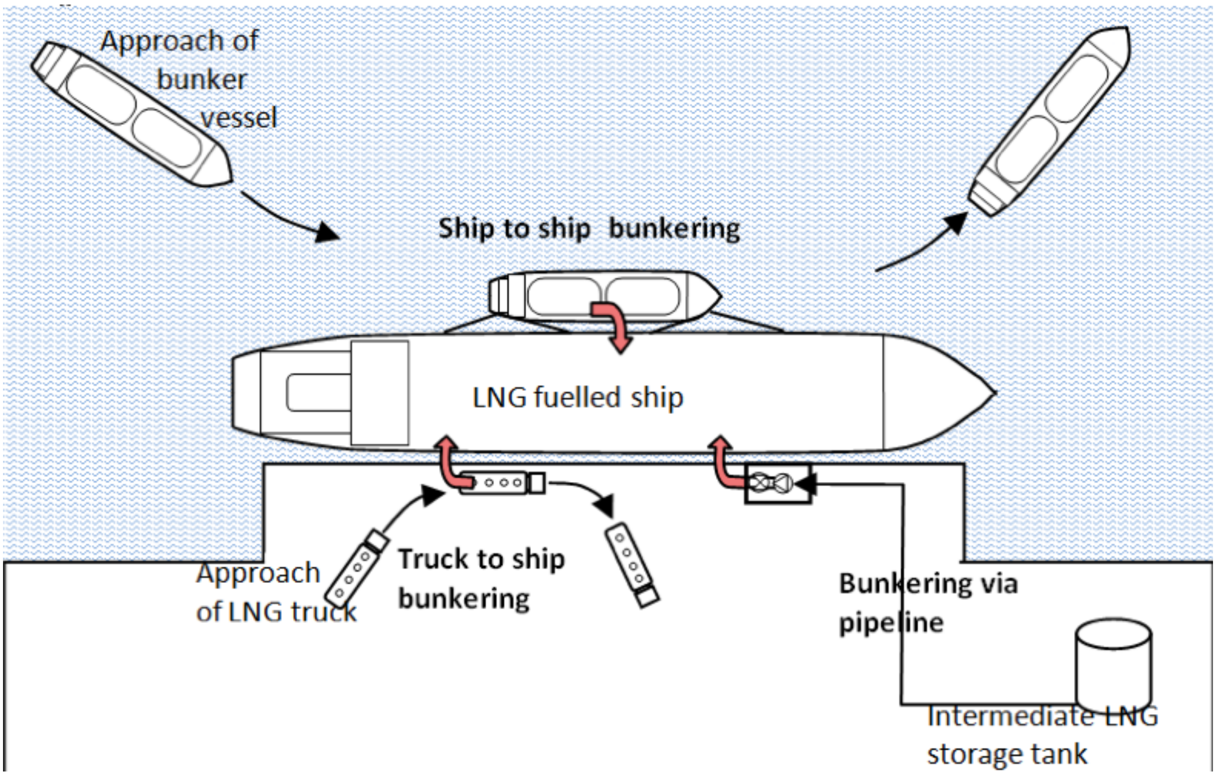
Small scale LNG is the method of distribution currently being used to supply LNG to ships for fuel. It is an effective solution for delivering gas to consumers without using pipeline networks but instead using various modes of transportation; trucks and ships (Figure 4). In terms of LNG suppliers to offshore ships in Norway, two gas companies dominate small-scale LNG as shown in Figure 3. Gasnor which is owned by Shell, consists of two plants, one commissioned in 2004 and the second in 2007. LNG production from the liquefaction plant is transported along the Norwergian coast using LNG vessels “Coral Methane” and “Pioneer Knutsen”. Skangass delivers LNG using truck loading facilities and LNG carrier Coral Energy. (IGU, 2014) In terms of LNG bunkering facilities, there are 5 available for LNG bunkering: Florø terminal, CCB Ågotnes terminal and Halhjem terminal in Bergen, Snurrevarden terminal in Karmøy and Risavika terminal in Stavanger. As seen in Figure 1, these bunkering facilities are located along the west coast which facilitate bunkering of LNG fuel for North Sea operations. (DNV, 2014)

Figure 3: LNG Suppliers in Norway per August, 2013 – Contracts for LNG supply until 2016.



Source: (NOX Fund, 2014)

Figure 4: 3 types of Bunkering solutions



Source: (DMA, 2012)

LNG Prices

Consumers of LNG in Norway today, as well as companies considering the use of LNG, lack a price-reference for LNG that is known and can be communicated to those wanting to acquire this knowledge. Clarity surrounding LNG prices are vital to making the investment decision to build or not a vessel with LNG propulsion as it is a factor that influences how attractive the vessel is to the customer. (Fund, 2013) This data is fundamental to analysing the development of LNG pricing in the long-run for customers. A report written by DNV in 2010 criticized “small scale liquefaction and expensive distribution” in Norway to be consuming the potential for cost savings LNG as fuel can potentially have. (DNV, 2010a) 16USD/mmbtu was recorded as the approximate price in 2010 whilst LNG bought on the international market on long-term contracts cost around 6-8USD/mmbtu. LNG prices in Norway are un-regulated and mostly undisclosed which have lead to higher unit prices than in the rest of Europe. The barriers to entry in small-scale LNG distribution are high as potential entrants are obligated to build their own LNG infrastructure or deliver LNG with trucks between long distances in order to compete for market share. (Fund, 2013) As a result, these high investment costs will make it difficult to compete on price with already established market actors.

LNG Price vs. MGO

Although LNG prices in Norway are rarely publicized, Platou were able to obtain a price reference for MGO and LNG as per May, 2014 for the purpose of this paper.

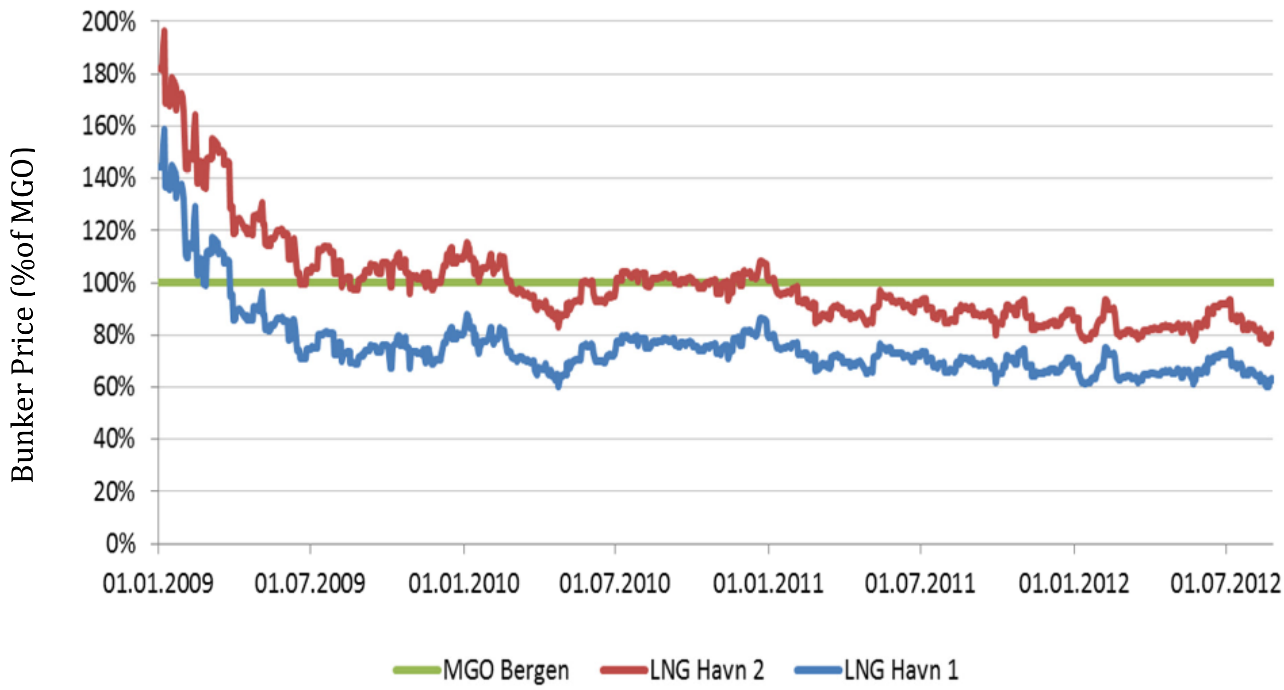
Figure 5: Statoil Price Reference for MGO and LNG as per May, 2014

MGO	5665,12 NOK per m3
LNG	**5,33 NOK per kg**

Source: Platou, 2014

According to Chevron, the density of MGO will typically be close to 860 kg/m3 (Chevron, 2012). Using that as a reference point, the MGO price in this scenario will be 6,59 NOK per kg. As per May of 2014, LNG is approximately 1.26 NOK per kg cheaper than MGO. Because there is more energy in one unit of LNG versus one unit of MGO, the cost benefit of LNG contra MGO is amplified. (LNG Bunkering, 2012). A study done by the Norwegian Business Sector using data provided by NOx fund members shows the trend of LNG prices from small-scale LNG actors from two terminals along the west coast of Norway as a function of MGO price between 2009 and 2012. (Fund, 2013) The graph shows a constant lower cost of LNG compared to MGO from 2011.

Figure 6: Price comparison of Marine Gas Oil (MGO) and LNG at two terminals on the West Coast of Norway (approximate)



Source: (Fund, 2013)

Current Regulations

Norwegian Environmental Tax on NOx emissions.

Norway ratified the Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone of November 30h 1999, which was adopted to the Convention on Long-Range Transboundary Air Pollution of 13 November 1979, also known as the "Gothenburg Protocol". (Unece.org, 2014) The protocol serves as a single agreement to cut certain pollutant emissions, NOx being included. Through this ratification, and the EU Directive 2001/81/EC stating in note 12,

"*Member States should be responsible for implementing measures to comply with national emission ceilings.*" *("DIRECTIVE 2001/81/EC," 2001)*

the Norwegian state committed to reducing its NOx emissions by limiting its national emissions to 156,000 kg of NOx per year. (Directorate of Customs and Excise, 2014) The

Norwegian state's strategy to reducing its NOx emissions and meeting its target was by implementing a NOx tax as stated in Section 1 of the resolution on tax on emissions of NOx.:

"As of 1 January 2013 and pursuant to the Act of 19 May 1933 no. 11 concerning Excise Duties, an excise duty shall be paid to the State Treasury - amounting to 17.01 kroner per kg for emissions of nitrogen oxides (NOx) during the production of energy - from the following energy sources:

a) *propulsion machinery with a total installed capacity of over 750 kW,*

b) *motors, boilers and turbines with a total installed capacity of more than 10 MW,*

c) *flares on offshore installations and on facilities on land."* (Directorate of Customs and Excise, 2014)

Nox Fund

Purpose

In 2008, two agreements were signed constituting the establishment of the NOx Fund. The first was the "NOx Agreement" between 14 business organisations and the Norwegian Ministry of Environment obligating the scheme, Business Sector's NOx fund to reducing NOx emissions by 30 000 tonnes by the end of 2011 in exchange for the fund's undertakings to be exempt from the Norwegian fiscal NOx tax on emissions. This exemption was granted by the European Surveillance Authority (ESA) ((ESA), 2008). The second agreement was the "Participants Agreement" between the Business Sector's NOx fund and its participants contracting the terms of which the undertakings must follow. The NOx fund follows a non-profit principle meaning that apart from administration costs which consist of about 2-3% of their revenue, all other revenue must be invested in NOx reducing measures or technologies.

The "NOx Scheme" agreement was entered into with the Norwegian Ministry of Environment on December 14th, 2010 ((ESA), 2011) committing the private fund to achieve a further reduction of 16 000 tonnes of NOx by the end of 2017, also known as the "2011-2017 agreement".

The Business Sector's NOx fund is an economic instrument that allows participants to apply for financial support for NOx reducing projects and/or measures. Support is dependent on the verified quantity of NOx reduced. Participants of the NOx fund are exempt from paying the Norwegian fiscal NOx tax of NOK 17.33/kilo NOx; the rate as per 1st of January 2014 (Directorate of Customs and Excise, 2014). Enterprises within the oil and gas production industry are required to make payments of NOK 11/kilo NOx, whilst other participant enterprises are required to pay NOK 4/kilo NOx emitted. The NOx board reviews applications and financial support is allocated to the applicants that are able to best reduce NOx emissions.

NOx fund support rate

For applications received after the 1st of January 2014, the rate of support is set at 300kr/kg NOx reduced by LNG propulsion on ships up until a maximum of 80% of the investment costs. (NOx Fund, 2013) The investment cost in this case would be the additional costs of building a LNG fuelled vessel against the conventional solution. The additional cost related to LNG powered propulsion on a PSV consists mainly of the engine, LNG system and installation. The NOx fund has found the additional costs of adopting LNG as fuel in a PSV varies slightly, however the average investment cost comes to NOK 49 million. ("NOx Fund," 2013)

The rate as per 1st of January is the new rate since being reduced from 350kr/kg NOx for LNG fuelled ships. This change in support means that ship-owners will now need to increase their NOx reduction by 14% in order to receive the same financial support from the NOx fund per year. Consequently, the ship-owner would need to ensure the vessel operates at a high enough level in order to be able to prove NOx has been mitigated by the reduction measure implemented. NOx reduction needs to be verified by DNV for support to be granted.

Expected Changes in NOx fund support rate

In an info-meeting regarding the status, changes and future of the NOx fund, the general manager of the Business Sector's NOx fund justified the high rate of support for LNG gas at 350kr/kg NOx as "purposely set high in order to stimulate a significant amount of vessels" ("NOx Fund," 2013) which has undoubtedly increased the use of LNG as fuel in Offshore Supply Vessels.

The support will be further reduced to 200kr/kg NOx reduced for applications after the 1st of July 2014. These reductions will mean that the rate of NOx mitigation will need to increase in order for the share of investment costs to be reached.

The reduced rate of support is coupled with the NOx Fund's diminishing availability of funds and its need to extend the durability of the remaining monies. ("NOx Fund," 2013) Further reasons stated for the reduced support to LNG measures on ships is the completion of the introductory phase for LNG moving into a more mature market which should correspond with lower LNG prices and equipment.

According to the NOx fund, a further reduction of support beyond the 200kr/KG NOx rate that will apply from 1st of July, 2014 is unlikely. The finite capital left in the fund will however determine how many LNG newbuilding applications will be granted support from the NOx fund. With regards to a lower support rate, only the vessels with the highest operational rate will be able to reach the full support allowance (G. Høibye, personal communication, 9th April, 2014)

NOx Fund support to LNG fuelled OSVs

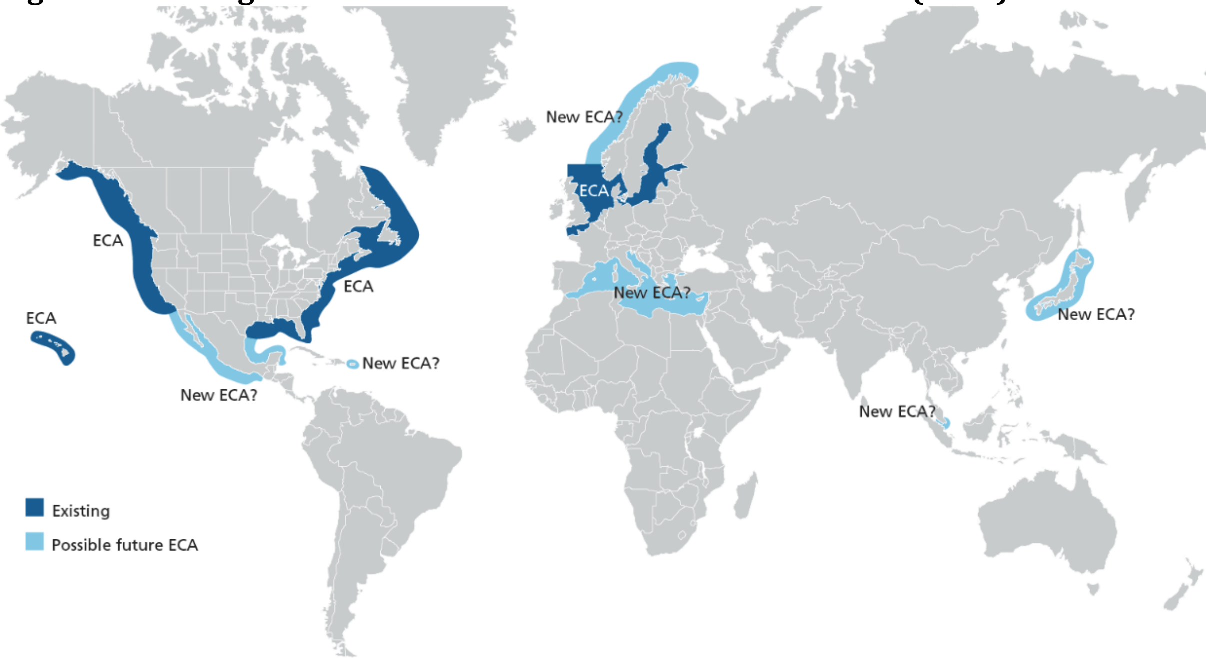
The NOx fund has granted support to 10 LNG fuelled PSVs as well as 4 more under construction. The NOx fund reviews applicants and determines the amount of support they will receive in accordance with planned operations per year. The head of the Business Sector's NOx fund stated the support to projects were based on the stability of the vessel's operation adding the projects not able to receive the maximum 80% support for their additional costs were due to little operation in Norwegian waters based on their average annual NOx reduction (T. Johnsen, personal communication, April 4, 2014).

NOx Fund after 2018

There is currently no agreement for the continuation of the NOx fund after the end of 2017. Considering the Norwegian legal framework, no continuation of the NOx fund will result in ship-owning companies again becoming subject to the Norwegian fiscal tax. Given that NOx fund members are today paying 4kr/kg NOx, this will mean a 325% increase given the present rate of 17.33kr/kg NOx is not altered. EU regulations for these types of agreements are however open to renewal meaning it will be up to the Norwegian government and the business sector to continue the current agreement. According to a NOx fund representative, this should be clarified in 2015 sometime.

Planned Environmental Regulations

Figure 7: Existing and Possible Future Emission Control Areas (ECAs)



Source:(DNV, 2011)

Sulphur oxide gases (SOx) are released when fuel containing sulphur is burned. SO2, a component of SOx forms acid rain when dissolved in water and can also form sulphates when interacting with air particles and other gases. These can be harmful to people and the environment. (EPA, 2014)

Sulphur Emissions Control Areas (SECAs) are established in MARPOLs Annex VI *Regulations for the Prevention of Air Pollution from Ships.* (Imo.org, 2011) SECAs are special areas that have stricter sulphur content requirements in bunker fuel. SECAs are made up of the North Sea, Baltic Sea, United States Caribbean Sea area and North American area. North Sea became part of SECA 22nd of July, 2005 and enforced the requirements 1 August 2007.

As the North Sea is part of SECA, vessels operating within this boundary have been obligated to limiting their Sox and particulate matter emissions in 1.00% since August 2007. Stricter requirements for SECA will see the allowance for these emissions be reduced to 0.1% from 1 of January, 2015. As of today, most offshore vessels run on MGO as fuel to meet the current requirements. The composition of this fuel is so that the content of sulphur is already very low. According to a DNV Petroleum Services representative, the MGO that is used today contains between 0.1% and 0.5% sulphur. Adjusting sulphur content to 0.1% from 2015 is not viewed as a challenge. (Veseth A., Personal communication, 2014) Although most PSVs are running on MGO today, implementation of SECA will boost demand for MGO as shipowners in other shipping segments will switch to this distallite fuel as a compliance strategy. (DMA, 2012) DNV supports this prediction in a report commissioned by the Norwegian Shipowners' Association furthermore stating that "the demand for distillate fuels as a result of global SOx regulations will lead to an increase in the price of distillate fuels" (Aalbu et al., 2013)

Relevance of research questions

We are seeing today, an interest in LNG as ship and concurrently ships being built with the technological ability to use LNG. In Norway specifically, there are 12 LNG fueled PSVs operating in the North Sea with 4 more on order. The current LNG infrastructure, although not as fully widespread along the Norwegian coast as marine gas oil, is able to supply LNG as fuel to ships operating in the North Sea. As a cleaner fuel, the environmental benefits are plentiful compared to MGO reducing SOx and particulate matter by almost 100%, NOx by 85% and CO2 by 25% in comparison. (DNV, 2010b) Although the additional cost of LNG propulsion about 20% of a ship-owners building cost, building a PSV with LNG propulsion is further incentivized by the Business Sector's NOx fund which refunds ship-owners as much as 80% of their LNG investment. The price of LNG, although admittedly still very high in Norway, is as per today lower than MGO and is expected to fall even more. With regards to the North Sea as an area of operation that can constitute short-sea shipping (OECD, 2001), with a functioning LNG infrastructure (Marintek, 2011), Norway is somewhat in a more developed stage of using LNG as fuel and has taken the lead in utilizing LNG as shipping fuel.(Lloyds List, 2013). Identified benefits and incentives for the use of LNG make it a viable fuel alternative (Marintek, 2013), whilst high building costs, LNG price ambiguity, and a not fully developed infrastructure still pose as challenges to be overcome. This paper aims to explore whether ship-owners are reaping the benefits of LNG and to what end the current environment for LNG as a fuel reflects the future feasibility of LNG fuelled ships being built.

Methodology

Research Method

The research method used for this study was semi-structured interviews. Finding limitied literature on this very current phenomenon, it was unclear to the researcher which questions would be the most important to ask, and therefore this research method seemed to circumvent the limitations that set questions in a survey or structured interviews would have put on data collection from each unit. While transcribing interviews, themes and trends that were identified could easily be developed during follow up interviews. With little conception of what the results would be prior to data collection, this inductive approach to research became the natural framework of my study.

A study into semi-structured interviews as a means of data collection found the method was useful to "explore respondents' opinions, clarify interesting and relevant issues, elicit complete information and explore sensitive topics within each interview, some freedom to probe was essential" (Barriball & While, 1994). This was applicable to my method of data collection as the data itself is of a sensitive nature and consequently care was needed when probing deeper into relevant matters.

Research Design

The research design is conducting interviews with 4 representatives working in the Chartering department of Norwegian Offshore companies that currently have LNG driven vessels in their operational fleet. The researcher also collects data from large Norwegian oil company, Statoil in order to have an overview of their procurement method with regards to choosing newbuildings for long-tern requirement contracts. Data is also collected from a second Oil company that is currently operating with LNG fuelled vessels on long-term contracts.

Sampling Method

Sampling frame

The sampling frame of my research consists of 4 informants that work in the Chartering department of Norwegian Offshore companies that currently have LNG driven vessels in their operational fleet. The sample consists of 4 from a population of 7 companies. By restricting the population to just companies with LNG vessels, the researcher is able to collect data based on actual operational experience with this technology and how these experiences have framed their current view on propulsion choice for newbuildings.

The researcher tried to the best of her ability to collect data from the informant that was representative to the company in question to insure reliability of the data. All informants hold positions in the Chartering department of each respective company and share to a close degree similar positions in the hierarchy of the organization. They are involved in day-to-day operations and have a comprehensive understanding of the market dynamics and factors involved in decisions related to newbuilding investments. .

After transcribing interviews, the researcher followed up on any inconsistencies that were identified with the informants as well as ask for clarifications where answers were not explicit. This was to avoid any distorted results based on the researchers potentially incorrect interpretation of the data.

All interviews were conducted over the telephone as distance between the interviewer and the informants prevented the possibility of face-to-face interviews. The interviews were recorded using a telephone application called "Tape A Call" which provided recordings of high quality. Permission to record the interviews were granted by the informants.

Using semi-structured interviews allowed the researcher to ask follow up questions in order to achieve more depth and understanding surrounding the primary response.

Ethical Considerations

The researcher has tried to the best of her ability to protect the anonymity of the informants. The researcher to the best of her ability did not indicate agreement or disagreement with the informants' responses to interview questions in order to obtain an ethically correct manner and avoid distortion of answers

Method of data analysis

After all the recordings were transcribed, the data was organized into answering 5 research questions:

1. What are the key factors that motivated the decision to build a LNG driven PSV?

2. What role has the NOx fund played in the building of LNG fuelled vessels?

3. Has LNG propulsion been a competitive advantage in a contract bidding process?

4. What are the conditions necessary for a LNG vessel to be built today?

5. How will a reduction to 250kr/kg nox reduced affect the ship-owner's investment decision?

Results

What are the key factors that motivated the decision to build a LNG driven PSV?

The first informant explained that the initial motivation to building with LNG was a result of expressed interest from a potential customer that wanted to explore the use of more environmentally friendly technology than what was currently available. “Focus was placed on reducing NOx and SOx emissions and found LNG to be the solution” (Informant 1, 2014) This prompted the design of an LNG driven which was later delivered on a long-term contract to the oil company.

Informant 2, 3 and 4 specified the high market focus on ships being as environmentally friendly as key drivers.

Informant 2 supports the focus on the environmental benefits of LNG with lower fuel costs for oil companies to increase attractiveness. The vessels were built with technical specifications intended for long-term charter contracts with a large oil company.

Informant 3 identified the high demand at the time for LNG vessels as well as many LNG vessels being built at the time as the most important key drivers.

Informant 4 stated numerous factors that resulted in the building of an LNG vessel. The most important factor for any newbuilding decision is meeting customer demand. “The operational benefits of LNG for the customer against a diesel engine were so that we assumed our business case would be rewarding enough to achieve a bigger likelihood to win a long-term contract.” (2014)

What role has the NOx fund played in the building of LNG fuelled vessels?

Informant 1 states, “Without it, gasboats will not be built”(2014).

Informant 2 supports this position, “I don’t think these boats would have been built if it wasn’t for the NOx Fund” (2014) (referring to the company 2’s LNG fuelled vessel).

Informant 4 states that the NOx fund made building an LNG vessel possible to meet customer demand for LNG vessels.

Has LNG propulsion been a competitive advantage in a contract bidding process?

Findings from the interviews with informants 1,2 and 4 show that the competitive advantage for ship-owners is that LNG reduces the fuel costs of the customer.

Informant 1 says that reduced fuel consumption is a competitive advantage for us. "Already today we can show our customers the figures proving the rewards of gas in a way that they can see and understand." (2014)

Informant 2 comments on the technical capabilities of the vessels, "The vessels in themselves are high performing and were competitive even in the spot market." (2014)

Informant 3 experienced during the building of their LNG vessel that a charter contract was needed to secure financing of the newbuilding project and therefore needed to compete on price. "We entered the market in a period where the vessel had to be offered in at a very low price in order to compete with regular MGO vessels."(2014)

Informant 4 states the vessel itself is considered "state of the art" in terms of its operational capacity. When operating on the spot-market, a premium was however not given in the hire rates, as it was a drawback for the charterer to organize LNG bunkering as well as not being able to load supplies on the vessel whilst bunkering was underway due to safety regulations. Bunkering could take about 7 hours depending on where the vessel was mobilizing. These were drawbacks that charterers could use to drive the hire rate down.

What are the conditions necessary for a LNG vessel to be built today?

Informant 1 states that's, "The NOx fund support is one of the most important conditions and of course that the government puts pressure on charterers to employ more environmentally friendly solutions… we feel that if the Norwegian government placed stricter requirements to, for instance, Statoil, then they would have far more gas boats than what they have right now"

Is LNG the fuel of the future for offshore support vessels operating in the North Sea?

(2014) In terms of future plans to build a LNG driven vessel, the informant in optimistic about LNG saying that their last 4 PSVs were built with LNG and this is a course they are planning to continue on. "without a doubt, LNG propulsion is highest on the agenda", in terms of fleet growth. (2014)

There is a strong consensus from informants 2,3 and 4 that in order for their respective companies to build a vessel with LNG propulsion, there would have to be a specific request from the charterer for LNG as the desired fuel.

Due to the high building costs, all informants have stated that the charterer must be willing to pay a premium for the additional cost of building.

Informant 2 follows by saying their next two newbuildings are not with LNG. The cost of building LNG vessels is high and the ship-owner is therefore dependent on higher day rates. Oil companies need to be willing to accept a part of the cost in order for it to be worth the shipowner's while.

Informant 3 follows by saying that he doesn't believe anyone would build a ship with LNG on speculation today and therefore a long-term charter would need to be attached to the newbuilding project.

How will a reduction to 250kr/kg nox reduced affect the investment decision.

Informants 3 and 4 responded that they either didn't know and that this was something that had not yet been looked into with regards to how it will affect the cost.

Informant 1 states that the investment decision is dependent on the development of the equipment prices comprising LNG propulsion. If the investment costs decrease to be equivilant to MGO then the NOx fond wont be a necessity. However as per today, the reduction of support will mean that the customer would have to cover this extra cost.

Informant 2 says that the reason they have built no more than 2 LNG vessels is largely due to the high cost associated with it. From the Owner's perspective, reduced support from the NOx fund will make building LNG more expensive, and a less attractive investment.

Figure 8: Results from Semi-structured interviews with Owners with LNG-fuelled ships: Summary

	Company 1	Company 2	Company 3	Company 4
What are the key factors that motivated the decision to build a LNG driven PSV?				
High market focus on LNG as green alternative	x	x	x	x
Customer demand for environmentally friendly technology	x		x	x
Reduced fuel costs for customer		x		x
High demand for LNG vessels			x	
Many LNG vessels being built			x	
What role has the NOx fund played in the building of LNG fuelled vessels?				
LNG Investment contingent on NOx support	x	x		x
Has LNG propulsion been a competitive advantage in a contract bidding process?				
Yes: Reduced fuel cost	x	x		x
Not identified			x	
What are the conditions necessary for a LNG vessel to be built today?				
Long-term requirement with LNG as fuel		x	x	x
Next NB will be LNG regardless	x			
Charterers pay premium for additional building costs of vessel	x	x	x	x

Procurement method of Statoil

For the purpose of understanding which factors impact Statoil's decision making with regards to newbuilding contracts, a representative from Statoil kindly outlined their procurement method of a newbuilding for a long-term contract

Evaluation process

Prior to any tenders, Statoil assess their future needs in relation to planned operational activity in the North Sea. If there is a long-term requirement for a PSV, Statoil outline the technical capacities that are required of the vessel for optimum performance. As such, an invitation to tender is sent to ship-owners where they are asked to offer a vessel in accordance to the specified requirements outlined in the tender. An evaluation process and evaluation model is designed to assess the offers made by selected ship-owners. The evaluation process involves ensuring the minimum requirements are met by the offered PSV. The vessel is also rated on technical capabilities that elevate its operational capacity, operational flexibility, environmental profile and qualities that otherwise provide an advantage for Statoil. The vessel is assessed against its desired hire rate in relation to the fuel consumption of the vessel in different modes of operation. The five modes are laying in harbor, moving back and forth from the installation using economical speed and maximum speed, waiting outside the 500m zone of the rig and lastly using dynamic positioning when operating by the installation. Fuel consumption is calculated in accordance to these modes, as the specific vessel will require different quantities of fuel related to the each activity.

Experience with LNG

From the operational data Statoil receives from the ship-owner as well as operational data they have gained from previous experiences with LNG fuelled vessels, it is found that when they are operating in high activity mode - sailing to and from the installation more than laying in DP mode, LNG fuelled vessels do use less fuel than that of a diesel run PSV. Consequently, ship-owners offering a LNG fuelled vessel will be more attractive to Statoil for the reason that it will consume less fuel which is a factor that has a direct cost impact on their evaluation. This is significant as the charterer pays for the fuel used by the vessel when it is onhire. In terms of LNG bunkering, Statoil has several bases where LNG is available allowing flexibility in their operations.

Position on fuel preferences

In earlier tenders before LNG vessels had properly established themselves in the market, Statoil would to some degree give preference to LNG driven vessels. Due to an increasingly stronger presence of LNG fuelled vessels in the market, the cost effectiveness of fuel consumption give LNG vessels enough of an advantage that they are no longer given any extra preference in a tender evaluation. Due to advancing technology in ship design, the benefits of LNG are being by rivaled by conventionally fuelled PSVs that are now placing substantial focus on improving fuel efficiency in combination with environmentally friendly elements allowing them to compete against LNG as a green alternative. Because it is per today not possible to state concretely which fuel alternative is better than the other, Statoil is maintaining a neutral position towards both fuels and will not discriminate towards one or the other in a tender evaluation process. Transparency regarding this position is also a key principle in their procurement method.

Statoil expresses strong interest in the debate surrounding which fuel solution is more environmentally friendly and changes in NOx fund support. If future research shows, and there is broad agreement that LNG-powered vessels are more environmentally friendly than diesel-powered vessels, then this might impact the evaluation model for future tenders as a decrease in NOx Fund support for LNG investment might reduce the ship-owner’s incentive to build such vessels.

With regards to the last major Statoil tender in 2012, there was no favoritism towards any fuel type. All offers were treated equally using the same evaluation criteria and as a result, the offers that were the most competitive whilst meeting the requirements of the tender was chosen. In this tender, one from seven PSVs that were awarded long term contracts was a LNG driven vessel.

Oil Company 2 experience with LNG fuelled vessels operating in the North Sea

Rewards of using LNG fuelled vessels

Due to the high cost related to building an LNG vessel, a premium is paid the ship-owner to use that is alleviated by the savings in fuel consumption. The largest advantages with LNG are the rewards in terms of its environmental benefits, mainly reduced CO2 emissions NOx that was a motivation to use gas vessels.

LNG infrastructure: a challenge?

The LNG infrastructure is developed enough to meet the needs of the oil company and bunkering is not a challenge. Extensive safety regulations surrounding the bunkering of the ships due to the notion that this can potentially be very dangerous mean there is a need for large safety zones when fueling the vessels. As large parts of the base are blocked off, no loading can be done simultaneously. Bunkering at nighttime and loading supplies and bulk in the mornings within working hours has solved this challenge. There has only been one instance we have had to send a PSV to work operating on MGO instead of LNG due to a considerable requirement for supplies on one of the rigs.

Have the reduced fuel consumption of the vessels met the expectations of the oil company?

The fuel savings are different from one vessel to another. The oil company experienced that the vessels that are pure gas are the most cost effective in terms of fuel consumption compared to dual fuel. (There are currently only two pure LNG fuelled PSVs on the market) Reduced fuel consumption does not meet the level that was expected. One LNG vessel has very similar fuel costs to another diesel-gas vessel operating for the same rig.

Future use of LNG vessels:

The decision to continue operating with LNG fuelled vessels is contingent on the charter price of the vessels and LNG remaining at the same level as what they are today.

Results in relation to the main Research question

Is LNG the fuel of the future for offshore support vessels operating in the North Sea?

In order for LNG to be the "fuel of the future" for offshore support vessels operating in the North Sea, there needs to be a motivation from the ship-owners side to build ships which facilitate the use of LNG.

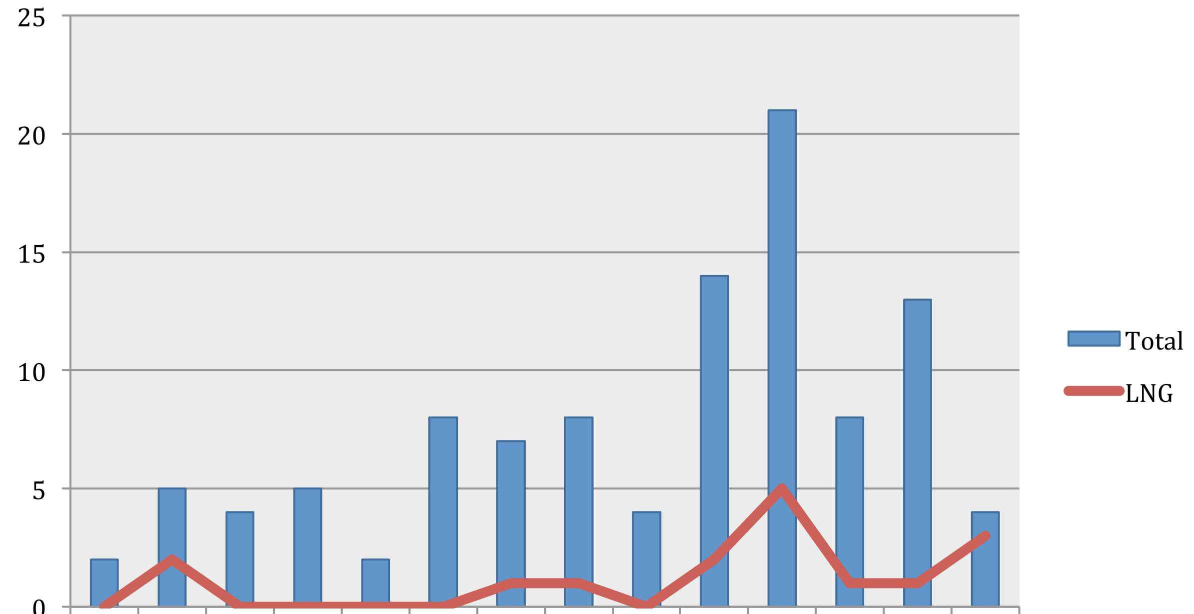
The results from the semi-structured interviews with Companies that own LNG fuelled vessels showed that the motivation to build LNG vessels have somewhat changed today from what they were when they ordered their first LNG vessels. Vessels were built in response to high market focus on LNG as a green fuel alternative in conjunction with customer demand for environmentally friendly technology and was contingent on support from NOx fund to compensate 80% of the additional investment. Results show that 3 of 4 shipowners are not willing to build a newbuilding with LNG on pure speculation. In order for a LNG vessel to be built today, 3 of 4 companies stated that the newbuilding project must be on the back of a long-term requirement for LNG fueled vessel. Changes in NOx fund support will also impact the investment decision-making process with half of the sample stating the changes will have a negative effect.

Findings from Statoil's procurement method show that as per today, in order for a Ship-owner to gain a newbuilding contract with a long-term requirement, choosing LNG propulsion is dependent on its commercial viability to Statoil in relation to competing offers. No preference is given to LNG as per today. If LNG-fueled vessels are proven to be a more environmentally friendly solution than diesel-gas solutions, the evaluation model may change for future tender proposals.

Findings from Oil Company 2 shows that there is a market for LNG fueled vessels based on their environmental profile. Oil Company 2 is a charterer that has taken on LNG vessels that have been built based on speculation on long-term contracts. Oil Company 2 stated that they pay a premium for the LNG fuelled vessels that they have on hire for the higher building costs of using LNG. The largest benefit of using LNG for this oil company were the environmental advantages in terms of reduced emissions. Reduction in fuel costs were not as great as expected, with one in particular showing minimal fuel cost reduction compared to a MGO vessel with a similar operational scope. Continual use of LNG vessels is contingent on the charter rate of the vessels as well as LNG prices maintaining the same level as per today.

Discussion

Figure 9: Delivery of Large PSVs operating in NSEA per year

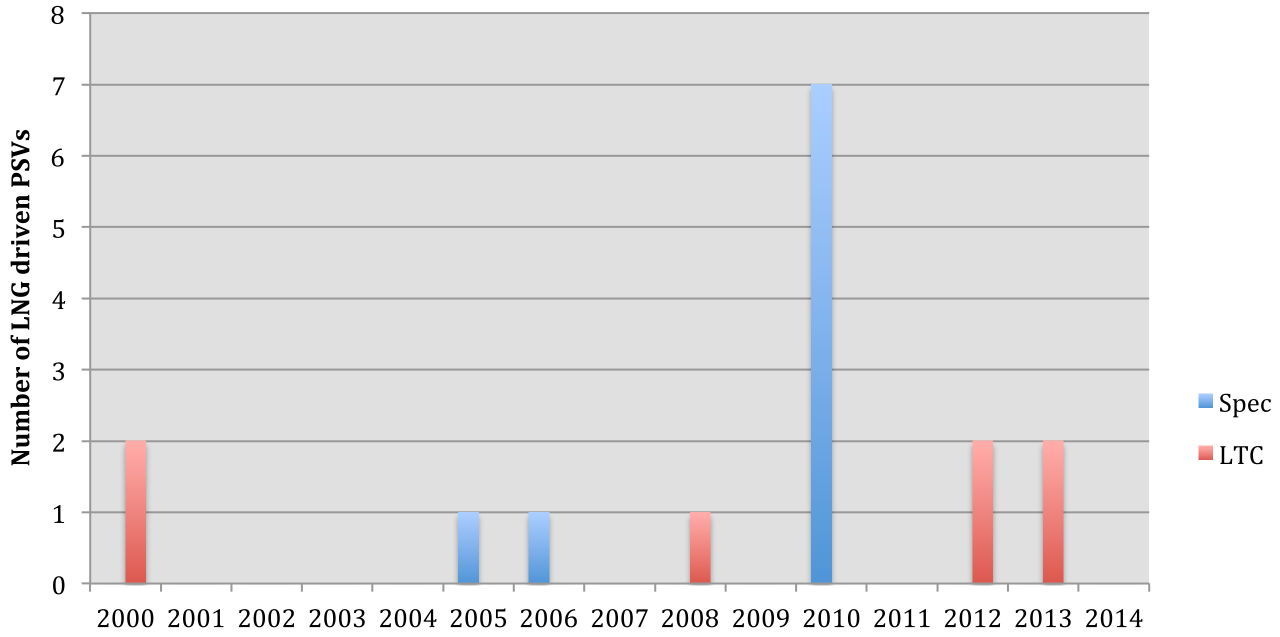


	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	2	5	4	5	2	8	7	8	4	14	21	8	13	4
LNG	0	2	0	0	0	0	1	1	0	2	5	1	1	3

This graph shows the trend between delivered LNG vessels as a function of the total number of PSVs that year with similar characteristics. To show a realistic overview of ship-owners selecting LNG propulsion over conventional propulsion, the data used to represent the total is strictly PSVs with a deck area over 900m2 operating in or with planned operation in the North Sea.

The graph shows the peak of LNG deliveries to this date was in 2012 when 5 LNG vessels were delivered, however this is in par with the high level of newbuildings that were delivered that year. The high delivery rate of LNG vessels in 2012 is a result of the 7 orders of LNG vessels that were placed in 2010 as seen in Figure 10.

Figure 10: PSVs with LNG propulsion: Year of order



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Spec	0	0	0	0	0	1	1	0	0	0	7	0	0	0	0
LTC	2	0	0	0	0	0	0	0	1	0	0	0	2	2	0

Year

Figure 10 shows the years in which orders were placed with the shipyards for the building of LNG fuelled PSVs. The graph differentiates between the vessels built on speculation, and those specifically built from a long-term contract award. The graph shows that there was a surge in orders for LNG vessels in 2010 with all 7 being ordered without a predetermined contract. Findings from the semi-structured interviews found that the key motivators for building LNG fuelled vessel was a high focus on greener technology coupled with a demand from customers for greener technology. In 2009, Statoil's project manager for "Green Logistics", Ellen Karoline Norlund stated Statoil were, "willing to pay more for vessels fuelled by LNG…We would like to charter more vessels that have a high environmental profile." (Statoil.com, 2009) At this current time, Statoil had all four existing LNG powered PSVs on long-term contracts (Appendix 2). This statement made in 2009 supports the informants understanding that there was a high demand environmentally friendly vessels, and that Statoil were willing to pay the premium for the extra building costs. Statoil's current non-preference to specific fuels results in no premium being allocated to LNG vessels in the evaluation process of a newbuilding tender. No alleviation for the higher building costs of LNG fuelled vessels diminishes the incentive further.

The graph also shows that after 2010, there are no PSVs with LNG propulsion that are ordered without an established employment agreement. This shows that LNG fuelled vessels ordered after 2010 have been on the basis winning long-term contracts. This supports the findings from the semi-structured interviews where ship-owners stated they will not build LNG fuelled ships on a speculative basis, only on the basis of a long-term contract award. The tendency that has been seen since 2010 to not build and LNG-vessel on speculation with regards to the researchers results further strengthens the validity of the sample's representativeness.

Oil company 2 is an example of charterer that is conscious of the extra cost (premium) of chartering a LNG fuelled vessel and is willing to pay it in order to benefit from the environmental benefits. When informant 4 was operating on the spot market prior to its current long-term contract, the drawbacks of operating with LNG (not being able to load supplies on vessel and bunker simultaneously) were used as a bargaining tool for the charterer to negotiate the hire rate down indicating that it is more difficult for a LNG fuelled vessel to defend their premium in the spot market. This further supports the argument that long-term contracts are preferable.

Limitations to the study

A limitation to the study is to what degree the findings from the sample is applicable to the all seven offshore companies operating with LNG vessels. Company one from the sample distinguishes itself from the population with regards to dominating share of LNG vessels in the market. Company one's attitude towards LNG as a fuel differed to the rest of the sample as they have a more vested relationship to LNG fuelled vessels subsequently a lot more to gain from the development of LNG as a fuel alternative in the Norwegian Sector. The results of the research would be more reliable if interviews were conducted on the entire population.

Conclusion

For LNG as fuel to be more widespread in the Norwegian offshore sector, oil companies need to be willing to pay more for the vessel in order to defend the ship-owners investment decision. Recent trends have shown that since 2010, not one LNG vessel has been built without a predetermined long-term contract with an oil company. This position was supported by the findings from the interviews.

Appendix A: Large PSVs operating in North Sea   Source: RS. Platou

Name	Type	BHP	DWT	Deck m2	DP	Design	Built	Flag	Yard country	Yard name
NORTH MARINER	PSV	9600	4320	950	DP2	UT 745	01.02.02	NOR	NOR	VARD SØVIKNES
VIKING DYNAMIC	PSV	12925	4500	985	DP2	VS 490	04.06.02	NOR	NOR	VARD AUKRA
STRIL MYSTER	PSV	12925	4500	985	DP2	VS 490	11.01.03	NOR	NOR	VARD AUKRA
STRIL PIONER	PSV	10936	4500	1030	DP2	VS 4403 LNG	20.04.03	NOR	NOR	KLEVEN MARITIME AS
VIKING ENERGY	PSV	10936	4500	1030	DP2	VS 4403 LNG	11.07.03	NOR	NOR	KLEVEN MARITIME AS
SKANDI CALEDONIA	PSV	8000	4200	912	DP2	MT 6000	15.11.03	NOR	NOR	FITJAR MEK. VERK.
FAR SYMPHONY	PSV	9920	4927	978	DP2	ULST. P105	06.12.03	NOR	NOR	ULSTEIN VERFT AS
VIKING AVANT	PSV	8160	5500	1040	DP2	VS 493 AVANT LNG	20.12.04	NOR	NOR	VARD LANGSTEN
BOURBON TOPAZ	PSV	9789	4927	995	DP2	ULST. P105	22.02.05	NOR	NOR	ULSTEIN VERFT AS
ISLAND PATRIOT	PSV	9928	4800	960	DP2	ULST. P105	11.04.05	NOR	NOR	ULSTEIN VERFT AS
NORMAND SKIPPER	PSV	12868	6400	1220	DP2	VS 4420	21.04.05	NOR	NOR	FLEKKEFJORD SLIPP
ENERGY SWAN	PSV	10330	5304	1060	DP2	ST 216L	26.05.05	NOR	NOR	VARD BRATTVAAG
STRILMOY	PSV	9928	4150	932	DP2	MT 6000 MK II	29.08.05	NOR	NOR	VARD LANGSTEN
STRIL ODIN	PSV	9928	4150	940	DP2	MT 6000 MK II	12.05.06	NOR	NOR	VARD BRATTVAAG
BOURBON MISTRAL	PSV	8568	4750	1003	DP2	ULST. PX105 CD	17.11.06	NOR	NOR	ULSTEIN GROUP ASA
BOURBON MONSOON	PSV	8568	4750	1003	DP2	ULST. PX105 CD	07.02.07	NOR	NOR	ULSTEIN GROUP ASA
ISLAND CHAMPION	PSV	9456	5000	1000	DP2	UT 776 E	11.04.07	NOR	NOR	VARD BREVIK
VOLSTAD VIKING	PSV	10300	5100	1060	DP2	ST 216L CD	27.04.07	NOR	NOR	VARD BRATTVAAG
ISLAND CHALLENGER	PSV	9456	5000	1040	DP2	UT 776 E	09.09.07	NOR	NOR	VARD BREVIK
EDDA FRAM	PSV	10445	4500	930	DP2	ST 216	10.09.07	NOR	SPN	ASTILLEROS GONDAN, S.A.
NORTH PROMISE	PSV	10700	4850	1000	DP2	STX PSV 09 DE	15.09.07	NOR	NOR	VARD SØVIKNES
VOLSTAD SUPPLIER	PSV	10300	5100	1060	DP2	ST 216L CD	20.10.07	NOR	NOR	VARD BRATTVAAG
SIEM SAILOR	PSV	9928	4800	1005	DP2	VS 485 CD	14.12.07	NOR	NOR	KARMSUND MARITIME AS
HAVILA FORESIGHT	PSV	12128	4800	1046	DP2	MT 6010 MKII	11.01.08	NOR	NOR	HAVYARD LEIRVIK AS
SKANDI MONGSTAD	PSV	12318	4200	1030	DP2	VS 495 DEM CD	27.01.08	NOR	NOR	KLEVEN MARITIME AS
VIKING QUEEN	PSV	10636	5000	1010	DP2	VS 493 AVANT CD - LNG	10.02.08	NOR	NOR	WESTCON GROUP
FAR SEEKER	PSV	9460	4500	1090	DP2	UT 751-E	13.02.08	NOR	NOR	VARD BREVIK
FAR SEARCHER	PSV	9460	4500	1090	DP2	UT 751-E	12.04.08	NOR	NOR	VARD BREVIK
VOLSTAD PRINCESS	PSV	10300	5100	1060	DP2	ST 216L CD	10.06.08	NOR	NOR	VARD BRATTVAAG
BOURBON SAPPHIRE	PSV	9785	4700	990	DP2	ULST. P105	17.06.08	NOR	CHR	SINOPACIFIC ZHEJIANG YARD
TROMS CASTOR	PSV	10440	5549	1005	DP2	VS 485 CD	16.02.09	NOR	NOR	HELLESØY VERFT AS
SKANDI FLORA	PSV	14600	5200	1025	DP2	STX PSV 06 CD	20.02.09	NOR	NOR	VARD AUKRA
FAR SERENADE	PSV	9465	5650	1000	DP2	UT 751-CD	02.04.09	NOR	NOR	VARD BREVIK
VIKING LADY	PSV	10777	6200	1000	DP2	VS 493 AVANT CD - LNG	15.04.09	NOR	NOR	WESTCON GROUP
EDDA FRENDE	PSV	10445	4500	930	DP2	ST 216	12.06.09	NOR	SPN	ASTILLEROS GONDAN, S.A.
ISLAND COMMANDER	PSV	9456	4000	1040	DP2	UT 776 CD	13.06.09	NOR	NOR	VARD BREVIK
ISLAND CHIEFTAIN	PSV	9456	4000	1040	DP2	UT 776 CD	10.09.09	NOR	NOR	VARD BREVIK
TROMS POLLUX	PSV	10440	4900	1005	DP2	VS 485 CD	09.11.09	NOR	NOR	HELLESØY VERFT AS
NORTH PURPOSE	PSV	10738	4826	1000	DP2	STX PSV 09-CD	01.03.10	NOR	NOR	VARD SØVIKNES
REM VISION	PSV	12318	5200	1030	DP2	VS 495 DEM CD	05.03.10	NOR	NOR	KLEVEN MARITIME AS
SIEM PILOT	PSV	11900	4800	970	DP2	VS 485 MPSV CD	08.04.10	NOR	NOR	EIDSVIK SKIPSBYGGERI AS
HAVILA CRUSADER	PSV	10440	4900	1005	DP2	VS 485 CD	07.12.10	NOR	NOR	HELLESØY VERFT AS
SKANDI GAMMA	PSV	10197	5012	1000	DP2	STX PSV 06 LNG	17.02.11	NOR	NOR	VARD AUKRA
REM HRIST	PSV	8570	4750	1002	DP2	ULST. PX105 CD	28.02.11	NOR	NOR	ULSTEIN VERFT AS

SIDDIS MARINER	PSV	11734	5000	970	DP2	VS 485 MPSV CD	20.03.11	NOR	NOR	KLEVEN MARITIME AS
KL BROFJORD	PSV	12000	5100	1102	DP2	STX PSV 06 CD	31.03.11	NOR	NOR	VARD BREVIK
REM MIST	PSV	8570	4750	1002	DP2	ULST. PX105 CD	05.05.11	NOR	NOR	ULSTEIN VERFT AS
REM COMMANDER	PSV	9057	5000	1000	DP2	VS 485 CD	02.07.11	NOR	NOR	KLEVEN MARITIME AS
BOURBON FRONT	PSV	7220	4500	1017	DP2	ULST. PX105 CD	06.09.11	NOR	CHN	SINOPACIFIC ZHEJIANG YARD
REM FORTRESS	PSV	9057	4500	1000	DP2	VS 485-CD	30.09.11	NOR	NOR	KLEVEN MARITIME AS
REM SERVER	PSV	13544	4700	1040	DP2	STX PSV 06 CD	21.10.11	NOR	NOR	VARD LANGSTEN
STRIL ORION	PSV	13544	4700	1040	DP2	STX PSV 09L CD	26.10.11	NOR	NOR	VARD SØVIKNES
ISLAND CENTURION	PSV	9464	4600	1000	DP2	UT 776 CD	29.10.11	NOR	NOR	VARD BREVIK
BRAGE SUPPLIER	PSV	9058	4800	1000	DP2	STX PSV 09 CD	03.11.11	NOR	IND	COCHIN SHIPYARD LTD
TROMS ARTEMIS	PSV	9785	5549	1005	DP2	VS 485 CD	25.11.11	NOR	NOR	HELLESØY VERFT AS
SKANDI FEISTEIN	PSV	9056	4700	1000	DP2	STX PSV 09 CD	28.11.11	NOR	ROM	VARD AUKRA
NORMAND ARCTIC	PSV	10649	4900	986	DP2	STX PSV 12 LNG	06.01.12	NOR	NOR	VARD LANGSTEN
OLYMPIC COMMANDER	PSV	12694	4800	1060	DP2	MT 6015-CD	19.01.12	NOR	NOR	KLEVEN MARITIME AS
REM SUPPORTER	PSV	12000	5300	1075	DP2	STX PSV 06 CD	03.02.12	NOR	NOR	VARD LANGSTEN
OCEAN PRIDE	PSV	8730	4000	900	DP2	HAVYARD 832-L	05.02.12	NOR	NOR	HAVYARD GROUP AS
STRIL POLAR	PSV	13508	4900	1055	DP2	STX PSV 09L CD	09.02.12	NOR	NOR	VARD SØVIKNES
ISLAND CAPTAIN	PSV	9500	4600	1000	DP2	UT 776 CD	17.02.12	NOR	NOR	VARD BREVIK
BRAGE TRADER	PSV	9058	4800	1000	DP2	STX PSV 09 CD	20.03.12	NOR	IND	COCHIN SHIPYARD LTD
VIKING PRINCE	PSV	9955	5800	1050	DP2	VS 489 LNG	30.03.12	NOR	NOR	KLEVEN MARITIME AS
OLYMPIC ENERGY	PSV	12868	5066	1000	DP2	STX PSV 06 LNG	26.04.12	NOR	NOR	VARD AUKRA
TROMS SIRIUS	PSV	11233	4868	1020	DP2	STX PSV 09L CD	03.05.12	NOR	NOR	VARD SØVIKNES
BOURBON CLEAR	PSV	8570	4450	1017	DP2	ULST. PX105 CD	31.05.12	NOR	CHR	SINOPACIFIC ZHEJIANG YARD
ISLAND CRUSADER	PSV	9450	4750	1000	DP2	UT 776 CDG LNG	01.06.12	NOR	NOR	VARD BREVIK
OLYMPIC ORION	PSV	12694	4800	1060	DP2	MT 6015	26.06.12	NOR	NOR	KLEVEN MARITIME AS
VESTLAND MISTRAL	PSV	9788	5549	1004	DP2	VS 485 CD	26.06.12	NOR	NOR	HELLESØY VERFT AS
EVITA	PSV	9788	5300	1000	DP2	VS 485 PSV MKII	30.06.12	NOR	NOR	KLEVEN MARITIME AS
VIKING PRINCESS	PSV	9955	5000	1025	DP2	VS 489 LNG	19.09.12	NOR	NOR	KLEVEN MARITIME AS
ISLAND CONTENDER	PSV	11019	4750	1000	DP2	UT 776 CDG LNG	27.09.12	NOR	NOR	VARD BREVIK
FAR SOLITAIRE	PSV	11281	5800	1022	DP2	UT 754 WP	04.10.12	NOR	NOR	VARD LANGSTEN
BOURBON CALM	PSV	9115	4450	1017	DP2	ULST. PX105 CD	02.11.12	NOR	CHN	SINOPACIFIC ZHEJIANG YARD
REM LEADER	PSV	9971	6500	1030	DP2	VS 499 LNG	10.12.12	NOR	NOR	KLEVEN MARITIME AS
HAVILA CHARISMA	PSV	7500	4700	1000	DP2	HAVYARD 833 L	15.12.12	NOR	NOR	HAVYARD LEIRVIK AS
LUNDSTROM TIDE	PSV	9928	4700	1000	DP2	STX 09 CD	09.01.13	NOR	NOR	VARD SØVIKNES
BOURBON RAINBOW	PSV	8570	4500	1017	DP2	ULST. PX105 CD	30.01.13	NOR	CHR	SINOPACIFIC ZHEJIANG YARD
ENERGY INSULA	PSV	9056	5000	1005	DP2	VS 485 MKIII	20.02.13	NOR	NOR	HELLESØY VERFT AS
FANNING TIDE	PSV	9928	4700	1000	DP2	STX 09 CD	15.05.13	NOR	NOR	VARD SØVIKNES
REM FORTUNE	PSV	8800	5275	1000	DP2	VS 485 MKIII	20.05.13	NOR	NOR	KLEVEN MARITIME AS
NORTH POMOR	PSV	12915	4000	1000	DP2	ST-216 ARCTIC	28.07.13	NOR	NOR	SIMEK AS
DEMAREST TIDE	PSV	9440	4700	1000	DP2	VARD PSV 09 CD	01.10.13	NOR	NOR	VARD SØVIKNES
EDDA FERD	PSV	13596	5500	1038	DP2	ST 920	25.11.13	NOR	ESP	ASTILLEROS GONDAN, S.A.
TROMS ARCTURUS	PSV	9792	5700	1170	DP2	VARD PSV 07	28.01.14	NOR	NOR	VARD AUKRA
NORTH CRUYS	PSV	12915	4700	1000	DP2	ST-216 ARCTIC	15.02.14	NOR	NOR	SIMEK AS
OCEAN STAR	PSV	9890	5000	1050	DP2	VS 485-L	17.05.14	NOR	NOR	MYKLEBUST MEK.VERKSTED
NS ORLA	PSV		4500	1000	DP2	UT 776-CD	01.06.14	NOR	KOR	HYUNDAI MIPO DOCKYARD
FAR SUN	PSV	9914	5700	1170	DP2	VARD 1 07	07.07.14	NOR	NOR	VARD LANGSTEN
OCEAN ART	PSV	9890	5000	1050	DP2	VS 485-L	15.07.14	NOR	NOR	MYKLEBUST MEK.VERKSTED
STRIL LUNA	PSV	10880	4500	1040	DP2	UT 776-WP	15.07.14	NOR	ESP	ASTILLEROS GONDAN, S.A.

NS FRAYJA	PSV		4500	1000	DP2	UT 776-CD	01.08.14	NOR	KOR	HYUNDAI MIPO DOCKYARD
SIEM SYMPHONY	PSV	10500	5500	968	DP2	VS 4411 DF LNG	01.08.14	NOR	NOR	HELLESØY VERFT AS
FAR SYGNA	PSV	9914	5700	1170	DP2	VARD 1 07	15.08.14	NOR	VNM	VARD VUNG TAU LTD.
REM EIR	PSV	9971	5900	1110	DP2	VS 4412 LNG	30.09.14	NOR	NOR	KLEVEN MARITIME AS
ISLAND CONDOR	PSV	9464	4600	1040	DP2	UT 776 CD	01.10.14	NOR	NOR	VARD BREVIK
SEA SWAN	PSV	8600	4700	1025	DP2	ULSTEIN PX105 CD	30.12.14	NOR	CHN	ZHEJIANG SHBLDG - FENG
ISLAND CLIPPER	PSV	9456	4600	1024	DP2	UT 776 CD	01.02.15	NOR	NOR	VARD BREVIK
STRIL VARD AUKRA 827	PSV	13521	3650	900	DP2	VARD PSV-06 LNG	01.02.15	NOR	NOR	VARD AUKRA
SIEM PRIDE	PSV	10500	5500	980	DP2	VS 4411 DF LNG	01.03.15	NOR	POL	REMONTOWA
REM KLEVEN VERFT 374	PSV		5000	1000	DP2	VS485 MK III ARCTIC DESIGN	01.04.15	NOR	NOR	KLEVEN MARITIME AS

Appendix B : Overview of LNG fuelled vessels

Soure: RS Platou

Year	Type	Design	Deck m2	Name	Owner	Yard	Area of Operation	Spot/LTC
2003	PSV	VS-4403(LNG)	1000	Stril Pioner	Simon Møkster	Kleven Verft	NSEA	LTC with Statoil. From 2003, recently declared options for 2 more years from july 2013.
2003	PSV	VS-4403(LNG)	1030	Viking Energy	Eidesvik	Kleven Verft	NSEA	LTC with Statoil firm until Q2 2015 + 4yr option
2008	PSV	VS 493 AVANT LNG CD	1000	Viking Queen	Eidesvik	Westcon	NSEA	Statoil/Lundin from Q4 2014. LTC with Statoil up until that point. Contract signed 2006
2009	PSV	VS 493 AVANT LNG CD	1000	Viking Lady	Eidesvik	Westcon	NSEA	Leiv Eriksson consortium 15 wells (MLS)
2011	PSV	PSV 06 LNG	1000	Skandi Gamma	DOF	STX OSV Søviknes	NSEA	LTC with Statoil firm until 2016 + 2yr opt.
2011	PSV	PSV 12 LNG	986	Normand Artcic	Solstad Rederi	STX Langstein	NSEA	"Normand Arctic" is chartered to BG Norge Ltd for a period of 2 years firm, with an option for the charterer to extend the contract by 1 additional year. Commencement of this contract will be late May -13.
2012	PSV	VS489 PSV	1021	Viking Prince	Eidesvik	Kleven Verft	NSEA	AGR supporting SS Bredford Dolphin
2012	PSV	PSV 06 LNG	1000	Olympic Energy	Olympic Shipping	STX OSV Aukra	NSEA	LTC with Statoil, 2 years
2012	PSV	UT 776 CDG	1000	Island Crusader	Island Offshore	STX Brevik	NSEA	LTC with Lundin. Firm 2,5yrs from 13.05.13 with several well options supporting SS Island Innovator
2012	PSV	VS489 PSV	1050	Viking Princess	Eidesvik	Kleven Verft	NSEA	LTC with Statoil firm until Q4 2014 + 1 yr option
2012	PSV	UT 776 CDG	1000	Island Contender	Island Offshore	STX Brevik	NSEA	LTC with Lundin. Firm 2,5yrs from 13.05.13 with several well options supporting SS Island Innovator
2013	PSV	VS499 LNG PSV	1032	Rem Leader	REM	Kleven Verft	NSEA	LTC Lundin until 17.05.14
2014	PSV	VS 4412 DF PSV	1080	Rem Eir	Remøy Shipping	Kleven Verft	NSEA	LTC with Statoil
2014	PSV	VS4411 LNG PSV	980	SIEM SYMPHONY	Siem Offshore	Hellesøy Verft	NSEA	Operational from 3 Q 2014 and will serve the Martin Linge oilfield, North-West of Stavanger, Norway. It has been designed to specifically meet TOTAL's North Sea operational requirements.
2015	PSV	VS 4411 LNG PSV	980	SEA PRIDE	Siem Offshore	Remontowa Shipbuilding	NSEA	LTC Norske Shell
2015	PSV	Vard PSV-06 LNG	approx. 950	TBN	Simon Møkster	Vard	NSEA	ENI Norge as - 10years firm
2015	PSV	VS 4411 DF		TBN	Siem Offshore	Remontowa Shipbuilding	NSEA	Undecalred options
2015	PSV	VS 4411 DF		TBN	Siem Offshore	Remontowa Shipbuilding	NSEA	Undecalred options
2016	PSV	VS 4411 DF		TBN	Siem Offshore	Remontowa Shipbuilding	NSEA	Undecalred options
2016	PSV	VS 4411 DF		TBN	Siem Offshore	Remontowa Shipbuilding	NSEA	Undecalred options

References

(ESA), E. S. A. (2008). EFTA SURVEILLANCE AUTHORITY DECISION
of 16 July 2008 regarding a notified scheme for the grant of a temporary exemption in relation to an environmental agreement between fourteen business organisations and the Norwegian State relating to reduction of Nitrogen Oxide ("NOx") emissions. Brussels.

(ESA), E. S. A. (2011). EFTA SURVEILLANCE AUTHORITY DECISION of 19 May 2011on the notified scheme for the temporary NOx tax exemption for undertakings encompassed by an environmental agreement with the State on the implementation of measures to reduce emissions of NOx in accordance with a predetermined environmental target. Brussels.

Aalbu, K., Amland, J., Balland, O., Bergsbak, H., Longva, T., & Opsand, S. (2013). Future Scenarios Towards 2030 for Deep Sea Shipping *Report for the Norwegian Shipowners' Association* (pp. 22): DNV.

Aas B., Halskau Sr Ø., & Wallace S W. (2009). The role of supply vessels in offshore logistics. *Maritime Economics & Logistics, 11*(2), 302-325.

Barriball, K. L., & While, A. (1994). Collecting Data using semi-structured interview: a discusion paper. *Journal of advanced nurcing, 19*(2), 328-335.

. The Business Sector's NOx Fund: Status, changes and future. (2013). In T. Johnsen (Ed.), *Info-meeting Oslo, Stavanger, Haugesund, , Ålesund, Tromsø Winter 2013/2014* (pp. 11-22): The Business Sector's NOx Fund.

Chevron. (2012). Everything you need to know about fuels. In M. B. Vermeire (Ed.), (3 ed., pp. 5). Belgium.

DIRECTIVE 2001/81/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2001 on national emission ceilings for certain atmospheric pollutants. (2001). *Official Journal of the European Communities*(L 309), 22-30.

Directorate of Customs and Excise. (2014). *EXCISE DUTY ON EMISSIONS OF NOx*. Oslo: Retrieved from http://www.toll.no/upload/aarsrundskriv/2014/2014 Emissions of NOx.pdf.

DMA. (2012). North European LNG Infrastructure Project. Copenhagen: Danish Maritime Authority.

DNV. (2010a). Greener Shipping in the Baltic Sea (pp. 7).

DNV. (2010b). LNG fuel for ships. A chance or a must? (pp. 2).

DNV. (2011). Emission Controlled Areas. from http://blogs.dnvgl.com/lng/wp-content/uploads/2011/02/1101-052-Kart-s7_v2.png

DNV. (2014). Gobal LNG bunkering Infrastructure: A status update as of January 2014. 2014

EPA. (2014). Sulfur Dioxide. Retrieved 6th April, 2014, from http://www.epa.gov/air/sulfurdioxide/

Fund, B. S. s. N. (2013). A Better Functioning LNG Market (pp. 8).

IGU. (2014). World LNG Report - 2014 Edition (pp. 45): International Gas Union.

Imo.org. (2011). Special Areas Under MARPOL. Retrieved 31 March, 2014, from http://www.imo.org/OurWork/Environment/PollutionPrevention/SpecialAreasUnderMARPOL/Pages/Default.aspx

Lloyds List. (2013). Shipowners eye potential of gas as an engine fuel. from http://www.lloydslistdcnawards.com.au/lldcnnews/december/weekly-edition-9th-december/shipowners-eye-potential-of-gas-as-an-engine-fuel

LNG Bunkering. (2012). The Use of LNG. from http://www.lngbunkering.nl/en_GB/use-of-lng.html

Marintek. (2011). LNG fuelled ships: The Norwegian Experience and Future Development: Marintek.

Marintek. (2013). Gas fuelled ships Norwegian experience (pp. 29): Marintek.

NOx Fund. (2013). Nye støttesatser for NOx-reduserende tiltak etter 1.1.2014 [Press release]. Retrieved from https://http://www.nho.no/siteassets/nhos-filer-og-bilder/filer-og-dokumenter/nox-fondet/stottesatser-for-soknader-mottatt-etter-1.1.2014.pdf

NOX Fund. (2014). *NOx-fondet og støtte til tiltak*. Paper presented at the Norwegian Gas Forum.

OECD. (2001). Short Sea Shipping in Europe *International Transport Forum* (pp. 12). Paris, France.

RS Platou. (2014). RS PLATOU GLOBAL SUPPORT VESSEL MONTHLY (pp. 4).

Shell. (2014). What is LNG? , from http://www.shell.com/global/future-energy/natural-gas/liquefied-natural-gas/what-is-lng.html

Statoil.com. (2009). Lower speed, lower emissions [Press release]. Retrieved from http://www.statoil.com/en/newsandmedia/news/2009/pages/10decspeedemissions.aspx

Unece.org. (2014). Protocol to Abate Acidification, Eutrophication and Ground-level Ozone - Air Pollution - Environmental Policy - UNECE. Retrieved 31 March, 2014

Wartsila. (2012). *Green OSV designs meeting high operational requirements*. Paper presented at the OSV Conference, Oslo.