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Tier III regulations in The Baltic and North Sea

Difficulties with implementing regulations and the impact on the volume and price of urea

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Abstract

In recent years, international organisations have increased their efforts to examine how they can achieve policy objectives more cost-effectively through better regulation or different mixes of policy tools. The concept of this research project was to conduct a study based on the constructivist approach of the grounded theory research method, aimed at developing a model for the efficient implementing of NOx regulations in The Baltic and North Sea. During the data collection, an additional research question was raised concerning the effect of the regulations on the marine urea price.

Findings were obtained by the means of in-depth interviews, conducted with government representatives, executives of international maritime companies, technical managers and techno-distribution companies. Specifically, the study seeks to identify the following issues: industries' opinion regarding postponement of the implementation date; what stimulates the shipping companies to use NOx abatement technology; if the future model may benefit from looking at the international practices of NOx regulations implementation; what features should the efficient implementation model have; and how the regulations may affect the marine urea market.

Overall findings led the study to suggest a model based on a combination of the present implementation method and a fund, inspired by the Norwegian NOx Fund. In addition, the study revealed an increasing demand for marine urea after the Tier III implementation. Notwithstanding the future fertilizer index, the costs of marine urea production and distribution are expected to be lower, resulting in a lower total customer price.

Keywords: Nitrous Oxide Emission Control Area (NECA), air pollution, Nitrous oxide (NOx), implementation problems, environment protection, urea, NOx Fund

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List of abbreviations

ECA	Emission Control Area
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
DNV	Det Norske Veritas
GT	Grounded Theory
GTM	Grounded Theory Methodology
HELCOM	Helsinki (Baltic) Marine Environment Protection Commission
IMO	International Maritime Organisation
IAPP	International Air Pollution Prevention
LNG	liquefied natural gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environmental Protection Committee
OCV	Offshore Construction Vessels
OECD	Organisation for Economic Co-operation and Development
NECA	Nitrogen oxide Emission Control Area
NOx	Nitrogen oxide
REPs	Refund emission payment programs
SCR	Selective Catalytic Reduction
SECA	Sulphur Emission Control Areas
SOx	Sulphur Oxide
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme

1. Introduction

Air emissions from ships are an increasing environmental concern (Stipa, Jalkanen, Kalli, & Brink, 2007). International shipping now contributes to about 15% of the global NOx emissions (Rahm, 2015). The principle exhaust gases from maritime transport, sulphur oxides (SOx), nitrogen oxides (NOx), CO2, CO, hydrocarbons, and particulate matter, have increasingly affected the air quality (Blumberg, Walsh, & Pera, 2016), especially in coastal areas (Volker, Bewersdorff, Aulinger, & Quante, 2010). Poor regional air quality, connected to ship emissions, are a concern because of their public health impact and greenhouse gas emission. Exposure to air pollution is associated with a number of health risks including premature death, cancer, heart and respiratory diseases (Han, 2010).

A key issue has been the limitation of Nitrogen Oxide emissions in Northern Europe. Since NOx emissions do not respect national borders and constitute a mutual responsibility, international agreements are required to protect the environment. Lately, the main regulatory instrument when it comes to air pollution by seagoing transport, the MARPOL Annex VI convention, has been amended to include nitrogen emissions. The Annex enforces a party or a group of parties to apply for Nitrogen Oxide Emission Control Area (NECA). In practice, it means an NOx reduction 75% in the area compared with the previous standard for vessels built after 2011 (Lindstad, Eskeland, Psaraftis, Sandaas, & Strømman, 2015).

Stringent NOx regulations led to the development of new NOx abatement technologies. Selective catalytic reduction (SCR) has appeared to be the only exhaust after treatment system technology that is able to bring vessel’s NOx emission to the level appropriate to NECA requirements. SCRs use the ammonia compound urea as a reducing agent. The Marine UREA 40% is injected into the exhaust and reacts with the NOx in a catalyst that breaks down the harmful NOx (nitrogen oxide) and converts it to mainly N2 (diatomic nitrogen) and H2O (water). I expect the implementation of the new environmental regulation will affect marine urea supply and demand sides.

This chapter introduces the research questions fundamental to this thesis. Further, the reasons for innovative implementation methods in environmental law are discussed. In addition, it will explain the importance of appropriate policy instruments choice, based on the interests of the regulated target group, some market effects and the regulatory context.

1.1 Research approach

Regulations in the field of environmental law have increased substantially since the late 1960s (Academy of European Law, 2016). A key element of international organisations' effectiveness is how well regulatory systems achieve their goals. Although we can note that increasing regulation and government formalities have achieved great results in some areas of economic and well-being, the results of new regulations implementation are still too often unsatisfactory (OECD, 2016). In recent years, public administration bodies, such as the European Commission, the International Maritime Organisation (IMO), the national environment ministries, the national environmental agencies and the US Environmental Protection Agency (EPA) have done considerable work in establishing and testing innovative implementation methods in environmental law (Academy of European Law, 2016).

Since 1990, more focus is being placed on the effectiveness of regulations objectives achievement. Full regulations compliance cannot be considered efficient if the regulations underlying design is imperfect and the chosen policy instruments are unappropriated (OECD, 2016). Thus, research on the most efficient implementation methods and different tools of policy mix are of interest.

To achieve regulatory objectives requires a clear understanding of the nature of policy instruments; the interests of the regulated target group; the effect on future markets and the regulatory context (OECD, 2016). Moreover, the feasibility of compliance is also crucial. For some industry players, the burden of complying with all technical rules may be unreasonable and too expensive (OECD, 2016).

International organisations, such as IMO, have a long term interest to gain global support from all nations. To achieve this, a regulatory design for the coming regulation is very important. By constructing a more realistic and compliance-friendly design, the organisation will likely improve its members' attitude to new regulations (OECD, 2016).

1.2 Research questions

In order to ensure effective enforcement of emission regulations it is essential to acquire thorough knowledge of their environmental effect and understanding of the most effective way of implementation (Marmer et al., 2009). The concept of this research project was to conduct a study based on the constructivist approach of the grounded theory research method, aimed at developing a model for the efficient implementing of NOx regulations in The Baltic and North Sea. During the data collection, an additional research question was raised concerning the effect of the regulations on the marine urea price. The study explores the latest NOx regulation for seagoing transport – Tier III, different parties' interests regarding NOx limitation, the Norwegian NOx reduction system, which is one of the most efficient models, as well as the regulations' consequences for NOx eliminating products, such as marine urea.

More specifically, I aim to answer the following research questions:

- R1: What is the most efficient way of implementing NOx regulations in the Baltic and North Sea?
- R2: How will the new NOx regulation affect the marine urea price?

1.3 Outline

This contribution is structured as follows: the introduction and problem statement, research approach and research questions of this study. Next, the theoretical part provides a review of the relevant research. The following section presents research design and grounded theory as the methodological choice adopted to answer the research questions. Finally, I analyse the findings from the interviews, in some cases supported by trade news, on the status of NOx regulations and propose a way of implementing the regulations in the Baltic and the North Sea, and our expectations regarding marine urea price.

2. Theoretical Review

A brief literature review was conducted of reasons for NOx regulation in the Baltic and North Sea, major international legal NOx preventing instruments, the example of national implementation and the overview of the status of Selective Catalytic Reduction (SCR) system and urea market. In grounded theory research, the existing literature is not used as a theoretical background. However, conducting a literature review prior to data collection and analysis commonly presented as a constraining exercise rather than a guiding one (Ramalho, Adams, Huggard, & Hoare, 2015). In addition, interviewers expect some prior knowledges from the researcher. The implications of doing a literature review in early stages of a grounded theory research are presented as related not only to the methodological approach, but also, and more importantly, to its epistemological framework. See section 3.1.2, bearing in mind that the literature review for this study started before data collection and the main work with the literature was done during data collection and analysis.

2.1 Statistics of NOx emitted by ships

A number of studies were conducted to estimate the contribution of shipping to the nitrogen oxide emissions in the North European and Baltic countries (Raudsepp, Laanemets, Maljutenko, Hongisto, & Jalkanen, 2013; Viana et al., 2014; Volker et al., 2010)**.** The studies show that about 9% of the total airborne Baltic Sea (Bartnicki, Semeena, & Fagerli, 2011) and 7% North Sea (Volker et al., 2010) nitrogen deposition comes from ships. Despite a relatively small fraction of ship nitrogen deposition, the shipping contribution rises to 50% in some areas and seasons (Stipa et al., 2007). The share of marine-born nitrogen oxides emissions is proportional to shipping activity in the region and increased by 7% between 2006 and 2009 (Jalkanen et al., 2009). Mentioned pollution accounts approximately for 50,000 premature deaths a year in Europe, at an annual cost to society of more than €58 billion, according to recent scientific studies (Transport & Environment, 2016).

2.2 The Impact of NOx Emissions from Shipping Operations on Environment and Human Health

The main constituents of air are nitrogen (N2) and oxygen (O2). During combustion, N2 and O2 react under the heat of the engine, forming nitrogen oxides. A variety of nitrogen oxides, such as nitrogen dioxide, nitric acid, nitric oxide, nitrates and nitrous oxide is commonly designated as NOx (Environmental Protection Agency, 1999). Further, the elements react with other substances, causing important effects on human health both through direct effects- decrease in lung function, chronic inflammation and irreversible structural changes in the lungs, respiratory symptoms, increased incidence/severity of respiratory problems, etc.; and through their role in the creation of low-level ozone. Moreover, due to their effects on acidification, they have been implicated in damage to forests, eliminates insect life and some fish species, acidates lakes and soils, causes deterioration of cars and buildings, etc. In addition, it accelerates algal growth and eutrophication of surface waters and block the transmission of light**.**

2.2.1 Impact of NOx emissions on the Baltic Sea

The combination of sea water from the Baltic Sea and fresh water from rivers makes the Baltic Sea to the largest brackish water basin in the world. The average depth of the Baltic Sea is only 53 metres and the water exchange with the North Sea is very slow. It may take several years between salt pulses from the narrow Danish Straits and the Sound.

Consequently, very few animals and plants can survive in such an environment that can be likened to a lake or estuary. The speciality of geographical position, oceanography and marine ecosystems make the Baltic Sea ecosystem unique and very exposed to pollution from human activities.

The growth of shipping activity and consequently, fuel consumption, has a negative effect on the environment and human health. More than 3,500 ships monthly operate in the Baltic Sea, which accounts for 15% of the world's cargo transportation (HELCOM, 2008). Atmospheric nitrogen deposition is estimated to contribute about 25-30% of the total nitrogen input to the Baltic Sea. The nitrogen deposition includes the NOx emissions from shipping, which are transformed by atmospheric reactions on their way from the ship's funnel to the site of deposition.

Eutrophication is considered the most challenging environmental problem for the Baltic Sea. "Eutrophication is a syndrome of ecosystem responses to human activities that fertilize water bodies with nitrogen and phosphorus, often leading to changes in animal and plant population and degradation of water and habitat quality" (Cloern, 2013)

Since the 1900s, the Baltic Sea has changed from an oligotrophic clear-water sea into a eutrophic marine environment. Eutrophication causes an enrichment of the ecosystem due to accelerated growth of algae and plant life caused by increased amounts of nutrients like nitrogen, which is a by-product of NOx emissions**.** These changes in the ecosystem negatively impact the biodiversity and alter the natural food-web structures, alter the composition of species and disturb population dynamics (HELCOM, 2011).

Research shows that 161 of 172 areas in the Baltic Sea, which represents more than 90% of the total coastal area, were affected by eutrophication (Pawlak, Laamanen, & Andersen, 2009). Cyanobacteria, which is one of the major indicators of eutrophication, has covered beaches in the northern Baltic and in the Baltic Proper (HELCOM, 2006). It has had a major impact on the tourism industry, inconvenience for recreational activities and the marine ecosystems in the Baltic Sea. Moreover, it causes reduced water transparency and low oxygen level in the Baltic Sea.

2.2.2 Impact of NOx emissions on the North Sea and the English Channel

More than 20, 000 ships operating in the North Sea make it one of the busiest transportation lines in the world. At any time, about 3000 ships are transiting the North Sea (Aulinger et al., 2016). In 2009, NOx emissions from these ships were estimated to be 472 000 tons. However, it should be noted that some other emission inventories for the same sea area have resulted in significantly higher figures of between 650,000 and 785,000 tons of NOx (AcidNews, 2012). The constant increase in the number and size of ships leads to even more air pollution in the North Sea coastal areas (Aulinger et al., 2016; Jalkanen et al., 2009; K Martinsen & A Torvanger, 2013)

Two studies conducted by the Netherlands Environmental Assessment Agency and the Danish Environmental Protection Agency, jointly commissioned by the eight countries bordering the North Sea, concluded that health benefits from the establishing of North Sea NECA are up to seven times higher than the costs and would provide total annual net benefits to society of up to €1646 million in 2030 (Danish Environmental Protection Agency, 2012; Netherlands Environmental Assessment Agency, 2012b). The control area will secure 75 % less nitrogen oxides emissions, resulting in substantial benefits for health and nature.

2.3 Annex VI of MARPOL

In response to the growing regional and global NOx emission impact as shown above, the International Maritime Organization (IMO) is tightening the emissions limits for NOx. Work done by the Marine Environmental Protection Committee (MEPC) resulted in the Protocol including MARPOL 73/78 Annex VI that was adopted in 1997 and originally entered into force on 19 May 2005, but has thereafter been revised by the MEPC in 2008. (IMO, 2016a). The Annex VI Regulations for the prevention of Air Pollution from ships apply to all ships of 400 gross tons and above. Vessels under this category have to carry an International Air Pollution Prevention Certificate (IAPP Certificate) that confirms compliance with the applicable regulations within the annex. Basically, the annex covers the following regulations:

- Regulation 12 - Emissions from Ozone depleting substances from refrigerating plants and firefighting equipment.
- Regulation 13 - Nitrogen Oxide (NOx) emissions from diesel engines
- Regulation 14 - Sulphur Oxide (SOx) emissions from ships
- Regulation 15 - Volatile Organic compounds emissions from cargo oil tanks of oil tankers
- Regulation 16 - Emissions from shipboard incinerators.
- Regulation 18 - Fuel Oil quality (IMO, 2016a)

2.3.1 Regulation 13

In this thesis I am interested in Regulation 13 that defines the permitted level of nitrogen oxides, fixed according to the speed, depending on the engine size. Regulation 13 describes three Tiers of standards of emission control. The Tier of standard relates to the vessel's engine and construction year. It applies to all vessels, fixed and floating drilling rigs and other platforms over 400 gross tonnage, and each diesel engine with a power output over 130 kW constructed on or after 1 January 2000 (IMO, 2016b; *Marpol 73/78 Annex VI. Technical and Operational Implication*).

Tier I

Tier I standard applies to all vessels driven by diesel engine installed from the 1 January 2000 to the 1 January 2011. Acceptable emissions of total weighted NOx depending on engine speed, n, are: 17.0 g /kWh when n is less than 130 rpm 45.0 × n(-0,2) g/kWh when n is 130 or more but less than 2000 rpm 9.8 g /kWh when n is 2000 rpm or more.

Tier II

Tier II standard applies to all vessels driven by diesel engine installed on or after 1 January 2011. Acceptable emissions of total weighted NOx depending on engine speed, n, are: n 14.4 g /kWh when n is less than 130 rpm n 44.0 × n(-0,23) g/kWh when n is 130 or more but less than n 2000 rpm n 7.7 g /kWh when n is 2000 rpm or more.

Tier III

Tier III will affect only vessels sailing in a specified Nitrogen Oxide Emission Control Area (NECA). While operating in NECA, vessels with a diesel engine of over 130 kW output power are required to meet the strictest Tier III NOx emission limits (IMO, 2016b). The regulation applies only to newbuildings and was to be enforced from 1 January 2016 in the U.S. Caribbean and North American coastal waters, as well as the Baltic and the North Sea. Acceptable emissions of total weighted NOx depending on engine speed, n, are: n 3.4 g /kWh when n is less than 130 rpm n 9.0 × n(-0,2) g/kWh when n is 130 or more but less than 2000 rpm n 2.0 g /kWh when n is 2000 rpm or more (*Marpol 73/78 Annex VI. Technical and Operational Implication*)

Tier	Ship constructed after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n > 2000
I	January 1st, 2000	17.0	$45 \times n^{-0.2}$ g/kWh	9.8
II	January 1st, 2011	14.4	$44 \times n^{-0.23}$ g/kWh	7.7
III	January 1st, 2016 (2021)	3.4	$9 \times n^{-0.2}$ g/kWh	2.0

Table 1. Limits for the emission of nitrogen oxide (n – engine speed)

The IMO encourages a party or a group of parties to apply for Nitrogen Oxide Emission Control Area (NECA). Environmental issue and background for NECA application could be summarized as follows. Firstly, an applying party should document on ships' emissions and its impact regarding health and nature. Secondly, the present economic impact of NECA on the maritime sector. Thirdly, compare cost effectiveness of NECA with land-based control. Despite the research documenting all of the above and proving the efficiency of NOx reduction technology (Hammingh, Holland, Geilenkirchen G.P., Jonson, & Maas, 2012; Incentive Partners & Litehauz, 2012; Kalli, Repka, & Karvonen, 2010), the date of regulations implementation was postponed in 2013.

2.4 Postponing the implementation of the regulations

Scandinavian countries have been seeking to establish the Baltic and North Sea NECA from 1 January 2016, - an issue which has been so far opposed by Russia (Baltic Port Organization, 2014). At the 65th meeting of the Marine Environment Protection Committee (MEPC) in March 2013 the Russian Federation submitted a document "Comments on the report of the Correspondence Group on Assessment of Technological Developments to Implement the Tier III NOx Emission Standards under MARPOL Annex VI" (IMO, 2013). The document declares a lack of technological readiness for NOx Tier III implementation and explicitly calls for an extension on the implementation of Regulation 13 (IMO, 2013). The Russian Federation noted that the whole review on abatement technology is focused on SCR as the only technology with practical application experience. The main grievances in the objection are the drawbacks of SCR usage in marine application. According to rapport produced by Russian Federation (IMO, 2013), the problems with SCR technology are:

1. … "the risk of ammonia, a gas no less toxic than NOx, appearing in the exhaust system when a diesel engine is working in variable load regime, due to the catalyst inertia. The system is reliable only within the narrow temperature range (250-400 °C). Furthermore, where NOx is neutralized with urea, emissions of greenhouse gas (CO_2) increase in the quantities approximately to those of the neutralized nitrogen oxides. In this connection, the Russian Federation is of the opinion that the SCR technology has not been discussed in detail and further discussion is required, as well as research into potential consequences of its application on board ships at sea…"

2. "It is recognized in analyzing the SCR technology that the high sulphur content causes bad catalyst deterioration. It is also concluded that such issues will not arise in sulphur emission control areas (SECA). The Russian Federation thinks it is important to note that if fuels with 0.1 per cent sulphur content are used in these areas, some ships will need to have scrubbers to remove sulphur oxides. Consequently, the need to install both SCR plants and scrubbers on board will present a complicated task due to the lack of space on board…"

3. "On analyzing the port infrastructure, the issue of urea availability for ships was the only one in focus, while there was no attention drawn to the problem on how to make catalysts available or how to dispose of them at the end of their operational life. The Russian Federation considers in this connection that the port infrastructure

readiness for the SCR technology has not been thoroughly considered and needs further consideration."

4. One notable concern is that these issues have not been solved even in the considerable time SCR systems have been in both marine and land application.

5. Expenses incurred as a result of regulations compliance may contribute to goods transportation by, for example, road transport, which will entail an even higher pollution level.

6. The other options for NOx abatement are very briefly described and cannot be considered as viable for implementation by the set date.

Russia received support from Poland, Latvia, Estonia, Greece, Cyprus and Malta. The decision was taken to postpone the Baltic and North Sea NECA from 2016 to 2021 and any future work on the NECA application. Russia received support from Poland, Latvia, Estonia, Greece, Cyprus and Malta.

2.5 Transboundary pollution

NOx emissions can be classified as a transboundary pollution, i.e. pollution that originates in one country but is able to damage another country's environment (Benchekroun & Ray Chaudhuri, 2014). NOx and the compounds formed from the elements may be dispersed by wind over the large territories, making the NOx emissions problem actual not just for the country of origin. This is complexity one tries to solve by the development of international conventions.

One particular issue with transboundary pollution is the variety of environment policies in different countries. Sub-optimization on a national level is leading to continued high levels of pollution, ignoring its effect in a global context. Thus, preventing emission from the regional perspective is clearly more efficient than on smaller national areas.

More than 90 per cent of the sulphur and 80 per cent of the nitrogen deposits in Norway originate in Europe (Norwegian Environment Agency, 2015). Air pollutants could travel several thousand kilometres before deposition and damage occurred ("Convention on Long-range Transboundary Air Pollution," 1979). Since NOx pollution is transboundary, it is difficult to judge what part of national deposited pollution is actually emitted in the same country. Throughout Europe, the prevailing wind direction is generally westerly or south-westerly. Consequently, a significant part of NOx deposition in Norway originates in the UK and the North Sea (Norwegian Environment Agency, 2015), while the UK emits much more than it receives. All the foregoing details prove that international regulations were necessary to solve problems listed in section 2.2.

To control the spread of transboundary pollution the United Nations Economic Commission for Europe (UNECE) ratified The Gothenburg protocol in 1999. The Protocol entered into force in 2005 and is a part of Convention on Long-range Transboundary Air Pollution. According to the protocol, Norway was committed to reducing its emissions of NOx to a level 30% below the emissions in the base year 1990, by the end of 2010 and to stay at this level (UNECE, 1999).

2.6 National implementation and NOx Fund

To be able to meet these requirements, a tax of NOK 17 per kg NOx was introduced in 2007. As a reaction to the tax, four years later fourteen business organizations representing undertakings emitting NOx, together with the Ministry of Environment on behalf of the Norwegian Government, have established a NOx Fund. 891 companies (per 5 Jan16.), now represent over 95 % of all emissions subject to NOx tax, are members of the Fund and therefore exempted from NOx tax. All companies, members of the NOx Fund, are eligible for financial support. The degree of support for specific measures depends on the type of NOx reduction measure, implementation cost and quantity of NOx reduction (K. Martinsen & A. Torvanger, 2013).

NOx Fund is a non-profit organization, established in order to support the enterprises to fulfil their obligations under the agreement. Members of the NOx Fund pay NOK 11 /kg NOx emission to the firm if they are in the offshore petroleum industry, and NOK 4 /kg if they are from other sectors such as shipping, supply vessels, fishing and aviation, instead of paying A governmental tax of NOK 17 /kg, and NOK 21.17 /kg from 2015, NOx emission. In addition, a company can apply for up to 90% refund of NOx technology installation costs, depending on the technology reduction effect (Confederation of Norwegian Enterprise, 2015).

I have examined three possible scenarios:

A company not being a member of NOx Fund and its ship not using any NOx reduction or measurement technology will pay 70 kg x NOK 21.17 /kg = NOK 1481.9 for each ton of consumed fuel, where 70 kg is an estimated average of nitrogen oxide released from 1 ton of bunker fuel.

A NOx Fund Member company, using NOx measurement technology on its ship, will pay approx. 50 kg x NOK 4 /k = NOK 200 for each ton of consumed fuel, where 50 kg is a measured average of Nitrogen Oxide released from 1 ton of bunker fuel (as per personal communication with NOx Fund).

A NOx Fund member company, using a Selective Catalyst Reduction (SCR) technology for its ship, but not a measurement technology, shall pay approx. (3.5 kg x NOK 4 kg) + (NOK 3600 /cbm –NOK 2500 /cbm) x 0.1 = NOK 124 for each ton of consumed fuel. 3.5 kg is the amount of NOx released from 1 ton of consumed bunker fuel subject to SCR technology that reduces emission by 95%, NOK3600 /cbm is an average urea price and NOK 2500 /cbm is a subsidy from the Fund.

After introducing the NOx Fund, NOx emissions have decreased significantly. The NOx tax and NOx Fund led to an efficiency improvement and NOx abatement technology installations, thus reducing NOx emissions from the maritime industry. In 2014, 142 000 tonnes of total NOx were emitted, more than 7 per cent less than the previous year. The reduction means that Norway achieved the 2020 emission target for NOX in 2014 (Stastistics Norway, 2014).

As indicated in the foregoing examples, membership of the NOx Fund seems to be advantageous from an environmental perspective. However, our question is if the Norwegian model may be used on the European or international level.

2.7 Tier III compliance technology

Stringent NOx regulations led to the development of new NOx abatement technologies. SCR has appeared to be the only exhaust post-treatment system technology capable of bringing a vessel's NOx emission to a satisfactory level in relation to Tier III regulation.

SCR was originally developed for stationary use, but has also proven to be effective in reducing NOx for a variety of mobile sources. The experience with marine SCR started in 1989 by the efforts of MAN B&W and Wärtsilä. Between 1989 and 1992 the system was implemented on four vessels and received acceptance and classification for the reduction of NOx emissions (MAN B&W, 1996)). Furthermore, between 1999 and 2000, Wärtsilä used a the example of three vessels in continuous operation to document NOx emission below Tier III standards (Wärtsilä, 2011).

Nowadays the SCR system is proven technology, tested on main engines, auxiliary engines and miscellaneous boilers. In addition, the system has proved the efficiency on a variety of fuels, including marine gas oil, heavy fuel oil and a combination of two of them. Moreover, the SCR system may be installed on existing engines by retrofitting the vessel.

However, it represents a significant investment depending on the engine type (The International Council on Clean Transportation, 2014).

The marine engine application evokes several concerns related to the catalysts optimization, urea dosing technology and urea infrastructure. A catalyst is needed to reduce nitrogen oxides by means of ammonia compound urea as a reducing agent. The marine urea reacts with the NOx in a catalyst that breaks down the harmful NOx and converts it to neutral N2 and water. The optimized catalysts ensure that a good NOx control level is attained, up to 95% reduction. Further, the SCR process requires precise control of the ammonia injection rate. Too low injection rate may result in unacceptably low NOx conversions, while too high – may release unwanted ammonia into the air, better known as ammonia slip. In addition, the logistics question arises.

2.7.1 Urea

With regard to urea infrastructure, land-based SCR systems utilize about 20 million tonnes annually. Currently, the total demand for urea from the maritime industry is less than 1% of the total land-based use (Briggs, 2014). We expect that implementation of the new environmental regulation will affect the supply and demand sides.

3. Methodology

This section provides an overall perspective of the methodology used for answering the research question stated in the first chapter of the thesis. It will describe research approach, data collection method, the interview guide, respondents, data analysis and ethical considerations.

Research is the process of collecting, analysing and interpreting data in order to understand a phenomenon (Leedy & Ormrod, 2001). In order to consider research as valid it should measure what it intends to (Jalkanen et al., 2009). A research study designed with regards to empirical requirements should answer research questions from section 1.2 and ensure relevant and reliable information that satisfies the purpose and the objectives of the study.

3.1 Research approach

The purpose of this research was to develop a model for efficient implementing of NOx regulations in The Baltic and North Sea through an exploration of the latest NOx regulation for seagoing transport – Tier III, different parties' interests regarding NOx limitation and the examples of the international practices. During the data collection, an additional research question was raised concerning the effect of the regulations on the marine urea price.

Considering that emission control from shipping in Europe is a sensitive issue being under negotiation at present, making it difficult to access current and accurate information, qualitative research approach was chosen for this thesis. I anticipated that a rich description would emerge from the data to inform and educate our understanding of what is important to consider while constructing an effective model of Tier III implementation in the area. Designing of the model is not an easy endeavour to quantify, therefore a qualitative approach was chosen for this study.

Qualitative approach is a holistic approach that involves discovery. The main focus is on inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories (Bryman, 2012). The researcher collects open-ended data the primary intend to develop a theory or pattern from the emerging data**.** The qualitative approach is flexible and often applied to understand a phenomenon from the participant point of view (Brinkmann & Kvale, 2008). This approach is typically selected to respond to research questions requiring textural data. Consequently, the researcher makes knowledge claims based primarily on advocacy/participatory perspectives or/and constructivist perspectives.

The research procedure began with the selection of the optimal data collection method for producing rich, research relevant data, followed by a collection of qualitative data. A pattern of meaning was generated from the data review, when repeated statements, ideas and proposals become apparent. The goal of the research was to rely on the participants' views of the entire situation. The assumptions about objectives of the study came from the meaning participants have about possible consequences if the Baltic and North Sea NECA would be implemented. Thus, constructivism claim knowledge applies for this study.

Constructivism can be described as a research that relies on the subjective meaning of participants, that may vary and multiple, encouraging the research to work on the complexity of views (Creswell, 2003). The research is characterized by unstructured interviews implementation and focus on the participants live and work context. The researcher's task, then, is to interpret the meanings others have about the studied subject. Rather than starting with a theory (as in postpositivism), inquirers generate or inductively develop a theory or pattern of meaning (Creswell, 2003). Constructivism is typical for qualitative research approach and often associated with research strategy Grounded Theory.

Given the research question (What is the most efficient way of implementing NOx regulations in the Baltic and North Sea?), it was important to choose a method that would illuminate the underlying cognitive processes associated with construction of the effective model of NOx regulation implementation. Due to complexity and discrepancy of interests amongst people engaged in the entire discussion, as well as the fact that the regulations are under negotiation at present, making it difficult to access current and accurate information - grounded theory (GT) was chosen as the most appropriate method to investigate the topic. The approach is considered to be valuable for analyzing a new developing area as the one addressed in this thesis. Applying grounded theory, the researcher may not always know what will be discovered. In this way, a sub-question (How will the new NOx regulation affect the marine urea price?) arose during the process of data collection.

3.2 Grounded theory

Grounded theory - is a qualitative approach involving the construction of theory through the analysis of collected data (Martin & Turner, 1986). Grounded Theory is an approach for developing theory that is "grounded in data systematically gathered and analysed" (Strauss & Corbin, 1990). Creswell (2003) describe grounded theory research as the “researcher attempts to derive a general, abstract theory of a process, action, or interaction grounded in the views of participants in a study” (p. 14). It operates often in a reverse direction from social science research in the positivist tradition, beginning from data collection that develops into a theory. The main feature of the grounded theory is that the theory is not taken from the research literature, but begin from the question or emerges from collected data. Appling ground theory, the researcher collects and reviews data, draws repeated ideas, concepts and elements and code them.

There are three main approaches to grounded theory methodology (GTM): classic, evolved and constructivism. All three approaches share the goal of developing a theory grounded in data, however differs in their opinion on literature review and the role of researcher. When the classic grounded theory was first introduced, the literature review before data collection and even after it was ignored (Glaser & Strauss, 1967). Later, the distinctness regarding literature renunciation became optional as long as the researcher “maintains an attitude of skepticism”(Strauss & Corbin, 1990). The evolve approach to grounded theory allow “technical” reading, or the literature that is related to the topic, but has not direct influence on the theory development. Both classical GTM and evolved GTM assume that objective knowledge can be discovered through a GT research by an appropriate use of the research methods, following the positivist/post-positivist paradigms (Gergen, 1990). The idea is that the researcher's influence on the research should be excluded by a proper use of research methods.

Alternatively, the knowledge may be constructed in processes of interchange between the researcher and participants (Flink, 2014). This approach to grounded theory is called for constructivism and differs by suggestion that it may be unattainable to exclude researcher's influential role. In addition, in constructivist GT research, a literature review is conducted before and during data collection, and previous reading often determines the field and the method of research.

In constructivist GMT, the results may be influenced by the researcher's view on the studied subject, and the effect of grounded theory is achieved by researcher's commitment to prioritize the data over any other input. The typical feature of constructivist GTM is that the researcher's voice in the discovered results should not be excluded or avoided (Ramalho et al., 2015). The idea of the approach is not to ignore existing knowledge, but to engage them.

The approach in this thesis is in the line with principals of constructivism version and confirms the important contribution of the literature review for the guidance of researcher through the studied topic and an indication of the current knowledge and work (Urquart, 2007). According to the constructivism approach to GT, literature review, data collection and analysis are overlapping processes from the beginning to the end of the research (Glaser & Strauss, 1967). Thus, grounded theory strategy accompanies a discovery of new theory and a constructivist approach allow to involve some previous knowledge for the theory construction.

However, it is essential to notice that, the collection and especially the analysis of the material in qualitative research may be very time-consuming. In addition, the strength of such research results is depending on respondents' willingness to share information and the competence with which the analysis is carried out. The research does not apply structured data, resulting in the risk of subjectivism as the data collected may be interpret in the wrong way (Bryman, 2012). In addition, too many descriptive detail and data reduction might be a great challenge for the researcher (Creswell, 1994). Therefore, "it is essential to reflect on ways in which your qualitative data and analysis could be affected by your standpoint and contextual understanding, as well as your expectations of the research, and to make this explicit within your research report" (Greener, 2008, p. 81).

3.3 Data collection method

The important element of research approach is the specific methods of data collection and analysis. When the researcher intends to specify the type of information to be collected before data collection, quantitative study should be chosen. If the researches allows the data to emerge from participants of the study, qualitative study should be the choice.

In fact, chosen research strategy will have a dramatic influence on the data collection procedures. Thus, the method was chosen according to the decision in previous section to apply constructivism version of GT.

In GT, qualitative data are derived from interviews and/or observations. The study looks after flexibility and high level of interaction with participants, that why the interview is considered as the most favourable method of data collection. According to Bryman (2012) there are mainly two types of interview in qualitative research: unstructured interview and semi-structured interview. Unstructured interview refers to the scenario where the researcher has only a list of topics to cover, while the semi-structured interview involves a list of questions that are in general form of an interview guide (Bryman & Bell, 2011).

In practice most GT interviews become semi-structutal because there is no need to focus on the development of the theory after the key issues emerged. Those that lack relevance to the emerging theory are not pursued. The questions intended to answer these key issues may be included in the interview quide (Holloway, 1997). If these issues do not arise spontaneously the researcher can then address them and secure the development of the emerging theory (Holloway, 2005).

This study aims to collect a variety of expert knowledge in a field from representatives of different institutions. To provide the study with in-depth relevant information, face-to-face and telephone expert interviews with suitable samples of experts in the field of environmental regulations, NOx abatement and urea market were adopted.

This approach was considered appropriate, as the study aimed to the construction of the efficient Tier III implementation model for The Baltic and North Sea, and to explore how the NOx regulations will influence marine urea price. All our experts have a direct involvement in the topic being discussed, thus the information would be reliable (Bohnsack, Marotzki, & Meuser, 2006). It provides detailed insight into emission protection on political, social and economic levels. In addition, experts were involved in the process of finding the most efficient model of the regulations' implementation. Respondents, chosen for the interviews, are all qualified experts, people with acknowledged familiarity in the research area. See below section 3.5 Respondents.

3.4 The interview guide

A final interview guide comprised one basic questions about the organization the respondent represents (e.g. mission, market position and position to the respondent); two questions about the use of NOx abonnement technologies by Norwegian shipping companies in Norway and outside national borders; three questions about their position regarding postponing of the regulations' implementation, six questions about NOx Fund work; and five questions about the future of the urea market; and one question regading strong features of the regulations' implementation model cf. interview guide, appendix 1.

The technique of McCracken's (McCracken, 1988) long-interviewing was adopted. The questions are generally generic, non-directive and introspective, open-ended in nature and semi-structured in form. An open-ended nature maintains the flexibility and freedom of discussion and semi-structured form is intended to enable the respondents to narrow down their experience. The current thesis presents the findings from the questionnaire.

Similar questions have sometimes been asked in different forms to ensure consistency of the received information. Sub-questions, as a result of received experience from the earlier interviews, were also added to ensure better information. To comply with McCracken's (McCracken, 1988) recommendations, a grand-tour technique was used. This type of questions contributes to a richer interpretation during the subsequent interview analysis process (Carlson & McCaslin, 2003). The questions require respondents to describe or reflect on their perceptions and experience.

The interviewer recorded all the information received from face-to-face interviews and noted all the information from the telephone interviews. First, the question was asked with possibility for the open answer. If the respondents were not specific enough by own wording, the interview then asked explicitly about that domain by the answer alternatives from the interview instructions. The interview instruction was developed in order to simplify the analysis of the answer.

Finally, the respondents were asked to share information they consider may be relevant for the research from their point of view. The objective of this question was to find out the objective opinion to the respondent what is important and whether the researcher should look closer into other aspect. To avoid misunderstanding, the interviewer shared the interpretation with the respondent for approval.

Each respondents' answer was summarized. In order to get a better overview and support the findings, all highlights and expressive quotations from the respondents were recorded.

The interview guide was piloted with two technical managers from two different shipping companies. The questions were generally understood well and some non-significant corrections were done. One question has been divided in two in order to clarify and simplify analysis.

3.5 The respondents

All respondents can be easily considered as "experts" in their field. The group was composed of a technical manager with a degree in naval engineering and more than 10 years' work experience in the technical department of one of the largest Norwegian offshore companies; two sales- and strategy department managers from urea producing companies with a degree in economy and chemistry and five to ten years' experience; urea trader with degree in nautical science and more than ten years at sea and fifteen years in trading company; two technology engineers with an education in naval engineering, experience as a chief engineers and more than ten years of experience in the shipping companies; representative from state environmental organizations with education from economy faculty and over thirty years from different state organization, including construction of environment regulation model in Norway.

The respondents are from three countries bordering The North Sea and The Baltic Sea (i.e. Norway, Great Britain and Russia) and can be considered as a convenience sample since this represents countries supporting NECA initiative and Russia, experts from economic, technical and environmental field, as well as political representatives. All respondents have a higher education, six of the respondents have more than twenty years' experience in the field, members of different environment organizations and are deeply involved in the research problem. The total sample consists of seven respondents, one from Great Britain, one from Russia and five from Norway.

Each respondent was contacted by telephone at a pre-arranged time. All face-to-face interviews were conducted at the respondent's work place. Interviews were conducted in English, Norwegian and Russian. All interviews were individual.

Data was gathered in the period from November 2015 to February 2016. The average duration of an interview was 1-1.5 hrs.

3.6 Data Analysis

Data analysis is defined as the interplay between researcher and data (Corbin & Strauss, 1990). In grounded theory, the procedures for analysis is quite free and emphasize creativity. Further, the constructivism approach enables the researcher to take the study beyond description, through setting connections between the previous concepts and theories, current settings and the findings.

The source data for this study consists primarily of the interviews. Additional data were gathered from trade news and analysis of the documents related to the topic.

The first stage of analysis was coding the data. Each interview was recorded and written down right after the researcher its conduction. The analysis process has already started after the first interview. Coding began with the detailed line-by-line analysis of hard copy transcripts. By coding the repeated key phrases, similar idea and interpretations, the elements of interest were identified. According to Strauss and Corbin, this process is called open coding. By means of open coding, a large amount of data was reduced to fractured fragments. Coding of ideas was allocated by use of phrases. Further, I continued to either expend or refine the conceptual categories and their dimensions by analysing the rest of interviews. This process was undertaken, looking for significant perspectives that related to the Tier III implementation process. A number of perspectives was drawn out from the first stage of analysis and used in the second stage of more focused coding.

The next stage, axial coding, began with the reassembling of data that were fractured during open coding. The categories and subcategories from the first stage being scrutinized**.** The goal is to systematically develop and relate categories for more precise and complete explanations about phenomena (Corbin & Strauss, 1990, p. 5). The aim of this procedure is to explore what are the initials of effective implementation model.

Finally, an analysis utilizes selective coding as a concluding step. Strauss and Corbin (1998) concluded "theory is validated by comparing it to raw data or by presenting it to respondents for their reactions" (p. 161). In an effort to obtain additional data (comments and feedback) from the participants regarding the topics addressed in the interviews, the results were discussed with the participants

Research on Tier III implementation in The Baltic and North Sea has been dominated by examination of economic and social challenges and contributions, only considered two scenarios: the regulations' implementation in form of model proposed by IMO or absence of the regulations at all. A challenging situation in the maritime sector leads to a need of new ideas, concepts and models that allow seeing business and environment in a joint perspective rather than a conflicting one. However, there is no need to neglect the existing model and practices and replace them by the new ones, but to modify them to more industry friendly version (Hoffman & Ehrenfeld, 1998). In this way, to allow solving NOx emission problem through more effective from the environmental perspective and more customer favourable solutions.

3.6 Ethical considerations

To protect study's participants, the ethical issues have to be concerned on all stages of the research. In addition, other ethical and legal considerations such as, data management, copyright, openness and honesty in communication, affiliation and conflicts of interest should be considered. Ethical standards are a basis for trust establishment between researchers and study participants.

The three core principle of ethical consideration are:

Informed contest requires the participants to be informed about the participation in the research and about the purpose of the study. Participants in this study were contacted via telephone and later received a letter of information about the school, the objectives of the study, description of the project, methods and procedures. The participants have been informed that the interview will be recorded and transcribed.

Confidentiality requires the anonymity for participation in and during the dissemination of the results. Based on the first code of Market Research Society guideline “the objective of any study do not give researchers a special right to include on a respondent’s privacy nor to abandon normal respect for an individual’s value” (MRS, 2011, p.16). Therefore, for some confidential reasons, the name of participants and even the name of company is held anonymous.

Safe treatment requires a commitment to minimizing the risks associated with research, including psychological and social risks. Due to the nature of this research the risks are minimized by the application of informed contest and confidentiality.

4. Findings

As a reminder, the purpose of this grounded theory was to generate a theory how to implement the Tier III NOx regulation in The Baltic and North Sea in the most efficient way for both society and industry. In addition, the study attempts to develop a theory on how the new NOx regulation will affect marine urea price. Glaser and Strauss (1967) stated; “generating theory puts a high emphasis on theory as process; that is, theory as an ever-developing entity, not as a perfected product” (p. 32). The discussion is based on the interviews combined with trade news and literature review.

In order to construct an effective model of regulations’ implementation, it is important to understand the industries’ opinion regarding postponement of implementation date, what stimulate the shipping companies to use NOx abatement technology and if the new model may benefit from looking at the practices of NOx regulations implementation at the country level. In addition, the experts were asked what features should the efficient implementation model have and how the regulations may affect the marine urea market.

4.1 The industries' opinion regarding postponement of implementation date.

Open code	Example Sentence
Complaints in the press	"I think I read something in press regarding industry complains regarding regulations postponement"
Bad for environment	"No doubt environment does not win from postponement"
Last-minute change consequences	"It is not serious to make such changes so short time before implementation."
Avoiding additional costs	"The industry has bad times now and it is bad time for additional costs."
Learn from North American ECA	"Not sure North American ECA contributes that much from the NOx regulation at the moment."
NECA will be enforced in 2021	"I hope and believe NECA will be implemented in 2021."

The decision to postpone the enforcement of regulations provoked a wave of complaints in the press. The industry has invested billions into developing the technology that will "heal and protect" the environment (Kettmann, 2013). The decision also raised concerns for the shipyard and ship-owners that had ships currently under construction. Their design aimed at providing space to fit Tier III compliant equipment as to originally regulations. Consequently, a challenge whether to install the NOx reduction technology or pay for re-design. Those already invested in the technology became completely disillusioned (Ships & Maritime Equipment Association, 2013).

Our experts agreed that the postponement of the enforcement of Tier III regulation from 2016 to 2021 has a negative impact on the environment, occupational health and endangering innovation. Some experts expressed a fear that any last-minute change of decision regarding implementation date may lead to questions about any future IMO decisions. One expert has been extremely critical to the decision and commented that from now on it will be difficult to trust the timeline for other regulations as well.

On the other hand, among the positive factors regarding postponing of regulations' implementation, some respondents have mentioned avoiding additional costs for ship operators working in an already competitive business environment due to overcapacity and economic downturn. In addition, some of them say that IMO might learn from North American ECA, where the NOx regulations in the similar formulation as for Baltic and North Sea NECA, has more negative than positive effect on environment.

Despite numerous studies (Azzara, Rutherford, & Wang, 2014; United States Environmental Protection, 2009) on the feasibility of IMO Annex VI Tier III implementation using SCR system, proving to be an efficient technology, the opposition to the proposed 2016 timeframe is mainly based on an arbitrary rejection of this technology (Ships & Maritime Equipment Association, 2013). Our experts' opinions regarding the postponing of the implementation date were divided. Some doubt that the technology has been tested to the extent that ship-owners can be sure they invest in the reliable NOx reduction instrument. They also believe that it is not the right time for shipping to undertake extra expenses and by this supporting The Russian Federation, thus postponing the regulations' implementation. Other argue that the right time will never come and the document submitted by opposition is nothing else than political play and an attempt to avoid additional costs.

Although there is some disagreement regarding undertaken measures, most of the respondents believe that the NOx reduction regulations will be enforced in 2021. The respondents also believe that the formulation of the coming regulation will be similar to the North American ECA, despite all the concerns regarding its effectiveness in the short term.

4.2 Reasons for use of NOx technologies

Open code	Example Sentence
Regulatory push	"We invest if we required to do so."
Sales argument	"I think NOx abatement equipment can be a good sales argument."
New trend of eco-friendly export and import	"I know some will prefer to buy food transported in the eco-friendly way."
Eco-friendliness helps to win contracts	"Look at the oil companies, they invest a lot in environment in order to have a good reputation and win contracts."
Economies of scale	"We do not invest because of environment, we invest because of money."

The adoption of eco-friendly technological innovations is driven by three factors: regulatory push, technology push and market pull (Horbach, Rammer, & Rennings, 2012). All respondents agree that for the shipping industry, regulations are crucial to operating in a more environmentally-friendly way.

The interviewed experts all agreed that ships intended to use an SCR system while operating in Norwegian territorial waters and to switch it off once entering non-regulated waters in order to reduce operational costs. However, there are a few exceptions**:**

France's Technip is well known by our respondents for use of their eco-friendly technologies as a sales argument. Thanks to eco-friendliness, this contributed to securing the company a new contract in Africa. Thus demonstrating added value compared with other operators by introducing NOx reduction equipment.

Some cargo owners require the transporter to be eco-friendly. Those managing to fulfil this requirement will be prioritized as their contractual partner. Charter company Cargill announced that they will only hire "eco" ships (Vineyard, 2012). The company is mainly involved in the transport of food and agricultural products. Being environmentally friendly creates a great promotion for the company.

Some of our respondents consider that eco-friendly import and export may be the new trend. In this way, the producer shows to the consumers that the products they buy are transported with minimum harm to the environment.

This also affects the oil industry, knowingly being a significant source of pollution. Our respondents say it is important for the oil companies to maintain a positive reputation in order to ensure contracts. This statement is also confirmed by numerous trade news articles and is written down in companies' policies. Exxon stated that the company will move towards green operations, reducing emissions and supporting research in the field of green energy (Rendon, 2015). The French company Total posts on its website that they work towards limiting the emissions from their oil and gas related activity (Total, 2016). As a part of company's environment program, Total has chartered a vessel Viking Lady, driven by fuel cell technology, from Norwegian ship-owner Eidesvik. The vessel is one of the most eco-friendly offshore construction vessels (OCV) ever built. She is able to reduce sulphur oxide by 100%, nitrogen oxide by 85% and carbon dioxide by 20% (Ship Technology, 2009). According to Maersk Line, a world leader of ocean freight, the Triple-E container vessel they operate the most efficient ship in the world. It is able to move every container producing 50 per cent less carbon dioxide than industry average. In all, the company plans to purchase twenty of such ships (Reyes, 2013).

Our respondents comment on the statements and underline that economies of scale surely is an important argument of the investments, while environmental arguments come as a nice add-on. Both technical managers acknowledged that their companies did not respond to "green" values as the main driver to install the technology. Regulations were in fact the main reason economical support was received from NOx Fund. The understanding that the company participating in creating of greener shipping is then an additional gain.

4.3 International practice

Open code	Example Sentence
Norwegian NOx Fund	"Look at how we do it in Norway…"
Swedish refund emission payment programs (REPs)	" I believe they have a similar to NOx Fund system in Sweden…"

The introduction of NOx tax in Norway leads to a significant increase in operational costs for the majority of shipping companies and effects competiveness of Norwegian companies, subjects to the tax. Due to presents of foreign businesses in various markets, Norwegian companies were not in the position to carry increased costs, such as the new environmental NOx tax. Thus, interest groups, especially cruise industry, protested against the introduction of the NOx tax (Axelsen, 2007).

The solution was found in the introduction of the NOx Fund. In accordance with the respondents, this Fund has been well accepted by the majority of tax- effected companies. It is a non-profit organization, so it neither creates income nor involves expenditures for the state. It attempts to solve the issue of competiveness and encourage innovation. The Fund does not grant support to research and development, but create a favorable environment for marketing of eco-friendly solutions and supports ready for implementation technology.

The main concern regarding effectiveness of Norwegian NOx Fund is if results justify the costs. Some interviewed experts are critical of the fact that the Fund's investment policy is biased and is promoting liquefied natural gas (LNG) more favorably than the SCR solution. LNG propulsion is seen as a green alternative, but not all are aware of the methane slip issue. Not controlled methane slip reduces environmental benefits of using natural gas and questions the eco-friendly status of the propulsion system.

Respondents have also mentioned that non-profit organizations, such as the NOx Fund, spend received money not in the same rational way as a profit company would do. It creates a situation where some environmental projects have been integrated without accurate pre-qualification.

Despite the respondents' concerns, the Norwegian NOx Fund model has received a lot of positive feedback from international organizations, foreign environment politics and scientists. For the contribution to the lower NOx emission, the Fund has been presented with the Green Ship Technology award in 2011 (Skips-revyen, 2011). Respondents say that the Fund model may also be used as a model for CO2 reduction in future. The Fund attracted attention from foreign governments, such as the Dutch and Swedes. Nevertheless, the Fund is still unique for Norway.

In addition, despite NOx emission in Norwegian territorial waters being regulated by Norwegian Government, and NOx Fund control the emissions from shipping, there are still some difficulties to address to ensure that all ships report the actual numbers of emissions. The system is based on self-reporting environmental monitoring, where the shipping company should self-monitor and regularly report NOx emissions released from their ships. Some respondents have doubted on reliability and comprehensiveness of the data, even though the NOx Fond attempts to ensure that the self-reporting system captures actual emission.

All our respondents agree that the fund system leads to greener shipping because of support given for NOx reduction. However, the support given differs a lot and resources are not equally distributed.

The interviewed experts have discussed three alternatives of implementing of NOx regulations: a refund emission payment programs (REPs), a fund and the original regulations' formulation. The latter being described in ch.2.

Refund emission payment programs (REPs) involve the return of generated tax revenues to companies based on their relative output levels (Fredriksson & Sterner, 2005). The program is implemented in Sweden as an emission control instrument. In short, this works by refunding the emission taxes to the tax-paying polluters in proportion to their share of polluting output. Although the abatement results are practically the same as for a tax of the same value, but taxpayers are more comfortable on the psychological level (Sterner & Turnheim, 2009). The respondents comment that the same argument can be applied to the Norwegian NOx Fund as well. The fee payed by members to the Fund is lower than tax imposed on non-members. This fact comforts the polluters and creates less averse to the system. Some of the respondents believe that if the Fund had been established from the beginning, without introduction of tax initially, the taxpayers would protest against the Fund, as they did with the tax.

Most of the respondents (5 of 7) consider that it is not possible to influence the implementation method of NOx regulation in North and Baltic Sea, or if one does so, it will delay the enforcement. However, six out of seven experts agree that either Swedish REPs or Norwegian NOx Fund, or combination of two of them, are preferable alternatives.

4.4 Features of effective implementation method

Open Code	Example Sentence
Flexibility	"One should get a choice to decide if they want to install SCR"
Fast result	"We will not feel significant improvement next 10-15 years"
Prevent cheating	"If there is a possibility to cheat the system, it will always be somebody who do it."
Limitation regarding ship's delivery date	"I believe it can help if one limits vessel's delivery date"
Equal chances for all	Small companies can also survive

Maritime industry characterized by international nature, high competition level and different attitudes to the environmental problems. Therefore, the explicit directives regarding pollution control may not always be the best solution for the problem. 6 of 7 experts participating indicated that they agreed on the importance of flexibility of environmental regulations. As one of the experts stated, when asked what was the most important key in order to receive approval from member countries and the industry in generally: “I think, the flexibility in environmental politic is extremely important”. As indicated, the flexibility is an important aspect for all industries and regarding most of the regulations, but it is particularly important for maritime industry due to its international nature and diversity of attitudes when it comes to environment.

Further, the experts have mentioned that even Tier III regulation in the current formulation will be adopted, it will take years before the overall emission rate will actually get lower. The reason for that is a slow turnover rate of ships, which usually being replaced after 25-30 years. The evidence to that can also be find in the research study to Netherlands Environmental Assesmennt Agency. In order to examine environmental impacts of NOx emission control, he developed two scenarios. The main NECA scenario describe all ships built after 2016 and operating in the North Sea will comply with the IMO´s Tier III NOx standards, thus reducing their emissions by approximately 75 per cent as compared to the Tier II standards. By 2030, this scenario would reduce total North Sea NOx emissions by about 30 per cent as compared to the baseline, down to 317,000 tons (Netherlands Environmental Assessment Agency, 2012a).

Moreover, the experts see at least two issues with the Annex VI regulation 13 saying that the regulations apply only to the ship’s keel laid after 2016. Firstly, the concerns regarding intensions from less environment-friendly ship-owners and operators to prioritize the vessels built before 2016 for the ECA trade after regulation implementation. The evidence is a significant newbuilding order activity at Chinese shipyards in 2015. This is also confirmed by a recent publication writing about the highest activity level in Chinese shipyards seen in the past seven years (Andersen, 2015). In order to meet the deadline and avoid additional expenses connected to NOx regulation, the new vessels' orders should be placed before late October 2015, so shipyards can lay down keels before the end of the year. Considering the fact that the lifetime of a modern vessel is about 25-30 years (Bimco, 2012), some respondents do not believe in the value of such a regulation over next two decades. Secondly, the respondents mention so called "cynically" dodging or the exploitation of Tier III loophole by Asian shipbuilders. In addition to the large order book from shipping companies willing to avoid additional costs, shipbuilders in China and Japan have been busy with laying of about 200 keels for vessels ordered by yard's integrated shipping companies. Ang and Corbet (2016) confirm the information presented by respondents and comment that tthese keels are clearly intended for resale to buyers willing to avoid Tier III regulations. It is a relatively small cost and effort for a yard to build a smaller keel and keep it for the period of time needed, and it is regarded as perfectly legal.

Some respondents argue that there should be at least a limitation regarding ship's delivery date. Avoiding regulations in a legal way is not a new practice. Some shipyards acted in the same way, when the performance standard for protective coatings for oil tanks was implemented, even the delivery period was limited. It will not protect against cheating, but curb it (Ang & Corbet, 2016).

The interviewed experts concern that for some industry actors the burden of complying with all technical rules can be unreasonable and too expensive. The reason for that is the cost of improvement may vary a lot depending on a ship design, engine type etc. In addition, the relationship between the cost of the arrangement for regulatory compliance and benefit from the entire investment, differs a lot. For some vessels retrofitting will cost not more than the price of the abatement equipment, while others may require hull restructuring or other significant investments.

4.5 The overall situation of the urea market

Open Code	Example Sentence
Urea infrastructure	“Infrastructure is quite simple and should not be a problem, as long as we have customers”
Distribution	“Distribution is absolutely manageable”
Ammonia slip	“Can be avoided if SCR works properly”
Price	“Distribution will be cheaper, so the customers’ price may go down”

Most of the experts agreed that there was no need to postpone the regulations as the technology has been through the necessary tests and the producers could provide evidence of its efficiency. This being opposed by the respondent from Russian shipping company, claiming the lack of technology readiness and infrastructure. Whether or not it is based upon a consensus among researchers, their view is also that since the shipping industry only generates a small percentage of NOx emissions in the Baltic Sea one should concentrate on other regulations.

One argument concerns the lack of infrastructure. However, according to our respondents’ view, the production of marine urea is manageable, in particular as it is a relatively small volume needed compared with other industries. Considering urea infrastructure, as per information from urea suppliers, shipping consumes not more than 1 % of the total land-based use. Typically, a small fishing vessel requires around 30 tonnes and up to 1000 tonnes for large cruise ships (Briggs, 2014). After the Tier III implementation, the demand for marine urea expected to increase slowly over time. Marine demand will continue to be a small part of the total urea consumption and production will easily manage to satisfy customer demands.

Distribution is not expected to create any significant problems, as vessels consume relatively small volumes. Urea is available worldwide and the number of ports to be served is expected to be limited. The producers are ready to expand the distribution system once demand is in place.

Another argument for postponing is that environmental bi-products such as ammonia slip and excess CO2 emissions will increase, but respondents state clearly that these are not generated in significant volumes if SCR systems work properly.

Looking at the future urea price, the interviewed experts agreed that distribution is the reason why the urea price differs a lot in different regions. Distribution costs are usually defined as the costs incurred to deliver the product from the production unit to the end user. However, there are also some other types of costs included in the customers' distribution cost, such as packing cost, storehouse, sales points etc. In order to predict possible development of marine urea price, one should look firstly at distribution price and then at urea price index, that is quite difficult to predict.

5. Discussion

This thesis aims to construct an efficient model of Tier III implementation in The Baltic and North Sea, and examine how current regulations will affect marine urea price. In the previous chapter I attempted to understand the following issues: the industries' opinion regarding postponement of implementation date; what stimulates the shipping companies to use NOx abatement technology; if the new model may benefit from looking at the practice of NOx regulations implementation at a national level, what features should the efficient implementation model have, and how the regulations may affect the marine urea market. This chapter presents a model of Tier III NOx regulations implementation in The Baltic and North Sea and discusses the future of the marine urea price.

5.1 A model of Tier III NOx regulations' implementation

In order to construct an efficient model featuring all the requirements on our experts, viz. flexibility, rapid results, cheating prevention, limitation regarding ship's delivery date and equal opportunities for all the industry's actors, one should look beyond the existing implementation model. Accordingly, the researcher and the interviewed experts agreed that the use of market-based instruments (MBIs) could be a solution. By applying MBIs, the governments or international organizations seek to address the market failure of "environmental externalities". This process will involve either incorporating the external cost of production or consumption activities through taxes, or charges on processes or products. Another option would be to create property rights and facilitate the establishment of a proxy market for the use of environmental services (OECD, 2007). Accordingly, well-designed and implemented MBIs encourage the industry's actors to undertake pollution control efforts, resulting in benefits for both industry actors and society as a whole.

A variety of MBIs is being tested and applied to different environmental issues around the world. However, even though MBIs differ from regulatory instruments, the implementing still requires some form of regulatory measures, such as taxes, charges, subsidies, emission trading, etc. As mentioned earlier, in addition to the original regulations formulation, cf. section 2.3, the interviewed experts have discussed alternative ways of implementing NOx regulations using refund emission payment programs (REPs) and a fund. Both models do not commit firms to reducing their emissions but instead, provide them with greater flexibility in their approach to pollution management.

MBIs may be very efficient within regional implementation as long as partners are open for international cooperation (European Commission, 2011). However, despite the documented efficacy and flexibility of market-based instruments, it remains an open-ended experiment as to whether we shall successfully execute a long-term social transition. Such a strategy involving the private sector and the state/international organisations in new relationships implied by the pollution prevention and economic instruments rhetoric (Kete 2002). In addition, putting the theory into practice involves overcoming obstacles and practical difficulties. Thus, it is crucial to review and test the model prior to its implementation.

Based on advice from experts, the authors propose a solution by combining the present implementation method with a fund based on the Norwegian NOx Fund model:

- All vessels having their keel laid after 2021 and delivered before 2025 need to comply with Tier III standards and are exempted from tax.
- All vessels equipped with NOx abatement technology are exempted from tax.
- Vessels having their keel laid before 2021 and not fitted with NOx abatement technology will be charged an amount of NOK/kg for each ton of NOx emitted.

In the most cases, the SCR installation on the newbuilding is not significantly more expensive than the cost of the entire system. Thus, the model proposes to uphold the condition that all vessels built after 2021 need to comply with Tier III. In addition, it will secure consistency in IMO's regulation decision and prevent complaints from those who have already invested in the technology.

All vessels equipped with NOx abatement technology that provide more than 50 % NOx reduction are exempted from tax. On this condition, the model allows vessels with alternative NOx abatement technologies, such as exhaust gas recirculation (EGR) and others that were installed before the regulations adoption, to continue operations in the area without extra payment, even they do not conform with the Tier III standard.

It was earlier discussed that the society will not experience any significant NOx reduction in the next 10-15 years, notwithstanding the increased level of emissions due to prioritizing of the older vessels for the operations in The Baltic and North Sea NECA by some shipowners.

For his reason, the proposed model applies to all vessel visiting the area and will secure a high level of NOx reduction from the first year of implementation.

However, despite undeniable benefits for the environment and for society as a whole, one should also consider the industries' interests. SCR installation consists mainly of equipment and retrofitting costs. While the equipment price is more or less similar, the cost of retrofitting differs a lot. The model allows different companies to achieve the same level of adjustment by the same investment, within acceptable limits. The proposed model encourages the firms to apply for compensation of retrofitting costs, thus making all the companies equal before the law. The model suggests that vessels having their keel laid before 2021 and not equipped with NOx abatement technology, will be chargedNOK…/kg for each ton of NOx emitted. In Norway, the current fee (NOK 4 per Kg NOx emitted, cf. 4.3 International practice) is regarded as manageable for the operators and may be used as a subsidy to compensate only for costs related to retrofitting of ships built before 2021, not including the technology as such.

There are several reasons for such a proposal. First, one may argue that there is a limited fund available, thus a need to prioritize. Second, as ships represent different cost structures, the shipowners' incentive to invest in relevant technology is distributed unevenly, leading to unfair competition amongst them. Thirdly, given a situation where the Fund has available resources after the proposed prioritization, only then a subsidy of technology-research costs. Organized as suggested, it will lead to a higher demand for the technology and thus stimulate equipment suppliers to invest in research and development.

Considering the economies of scale, we further suggest that vessels that are seldom operating in the NECA area and those having only a few years lifetime left cannot apply for support. For these vessels, the installation of NOx abatement technology simply will not justify the cost.

However, the issue may be to finance the investments. In Norway, the oil and gas industry pays a higher amount than shipping, NOK 11 /kg, compared with NOK4 kg., their share being the largest of the Fund's total. Europe's oil and gas industry outside Norway is smaller in comparison. Hence, the balance between fees and subsidies differs. This financial gap may also be partly covered by resources received from older vessels and vessels not frequently operating in NECA.

The proposed model gives the opportunity to achieve efficiency gains over implementation model proposed by IMO. The key reason to adopt the proposed model is it's potential to deliver better outcome with regards to environment and overall net social cost at generally lower financial investments to industry. Furthermore, the model prevents cheating regarding the keel laying date. Moreover, it allows flexibility and equalizes different companies' conditions.

The suggested model demands a thorough implementation procedure to function successfully in The Baltic and North Sea. We suggest more research regarding the level of taxes / and or fees; if too low, it will not encourage technology investments; if too high, owners of older vessels may be forced out of business. The balance between the two being an acceptable level. In addition, one should develop a model for calculating NOx abatement efficiency for each type of vessel. It will facilitate the application process and provide easily accessible information for shipowners about applying for subsidy for a particular vessel.

The applicability of the tax model to a ship's keel laid after 2021 should also be estimated.

5.2 Future of marine urea price

Our experts advised that there is a correlation between urea and gas/oil/coal price. However, the marine urea price does not correlate to generic urea prices. To simplify the calculation, I assume the price of marine urea consist of fertilizer price presented by urea index and extra cost due to low production (sales) volumes. Urea price statistic is indicative only for urea to be used as a fertiliser, which is a different grade to marine urea. As fertiliser is mass produced it enjoys a lower cost per unit, unlike marine urea that is produced in batches at a higher cost. In addition, distribution constitutes a great part of the customers' urea price. Our experts assume that after Tier III implementation the larger volumes of marine urea will be required. It will lower the cost per unit and improve distribution faculties, resulting in lower marine urea price in total.

6. Conclusions

It is expected that the use of NOx reduction technologies will become mandatory for new ships while operating in The Baltic and The North Sea as from 2021. However, Tier III standards will apply only to ships whose keels were laid after the 1 January 2021. As a ship's average estimated lifetime is about 25-30 years, Europe may experience a relatively high emission level during the first years after regulations come into force. Thus, it is essential to find an approach that will encourage the industry to invest in greener shipping.

In order to protect the environment and compromise with the industry, a model based on a combination of the present implementation method and a Fund, inspired by Norwegian NOx Fund, were proposed. Applying the model, all vessels having their keel laid after 2021 must comply with the Tier III regulation. Secondly, all vessels using SCR technology with urea are exempted from paying a fee. Thirdly, vessels having their keel laid before 2021 and not equipped with NOx abatement technology will need to pay an amount of NOK/kg for each ton of NOx emitted**.** Fourthly, the applicability of the tax model of ships whose keels were laid after 2021, not frequently operating in NECA and not equipped with NOx abatement technology, should also be estimated.

The collected fees may be turned to a subsidy and used primarily to compensate for retrofitting ships built before 2021. Available resources after the proposed prioritization may be utilized as an investment in technological research. Thus, the model represents a balance between environmental protection and industrial interests.

After the Tier III implementation, the demand for marine urea is expected to increase over time, depending on the implemented model. Disregarding the future fertilizer index, the costs of marine urea production and distribution are expected to be lower, resulting in lower total customer price.

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Appendix 1

Our research questions were developed as follows:

1. Please tell about the organization you present, e.g. mission, market position and your position and years of experience in the company);

2. Use of NOx abatement technology

• Describe your experience regarding use of NOx abatement technology in Norwegian territorial waters by Norwegian shipping companies.

• Describe your experience regarding use of NOx abatement technology outside regulated areas by Norwegian shipping companies.

3. The postponement of the implication date

• The regulations were supposed to come into force from 2016. How would you estimate the implementation from 2021, and not 2016? Please explain.

• What do you consider to be the main reason for change of the implementation date?

• What do you consider to be the biggest challenge for Tier III implementation in Baltic and North Sea?

4. The future of the urea market

• Do you consider the availability of NOx abandonment technology as satisfactory?

• Do you consider the urea infrastructure in North European countries as satisfactory?

• How will the regulations influence the volume of required marine urea?

• Do you think the marine urea suppliers will be able to meet customer expectations regarding regulations being implemented in 2021?

• What do you think the pricing policy of marine urea suppliers will be?

- Describe the marine urea market after regulations implementation.

5. Norwegian NOx reduction system and NOx Fund

- Do you consider NOx Fund’s work to be effective?
- How do you estimate the Norwegian model of NOx reduction?
- Can it be used as an example for other countries?
- Can it be used as an example for coming regulations?
- Do you believe the Norwegian system is more effective than systems in other countries?
- Explain your point of view on the coming regulations. What could be the most effective way of their implementation?

4. What do you consider to be strong features of the model for the implementation of the entire regulation?
5. Do you want to share some more information you believe can be useful for research?