

**A Comparative Study of the Northern Sea Rout (NSR) in  
Commercial and Environmental Perspective with focus  
on LNG Shipping**

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A Comparative Study of the Northern Sea Rout in Commercial and  
Environmental Perspective with focus on LNG Shipping

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## Abstract

Thawing sea ice in the arctic due to global warming has opened up new horizons for an environment friendly and cost efficient trade route between Europe and Asia. As an alternate to the Suez Canal, the Northern Sea Route (NSR) offers 50% shorter sailing distance between Northern Europe (Hammerfest) and Northeast Asia (Tobata). The shorter distance via the Northern Sea Route comparatively accelerates the route's cost efficiency by 42% and leads to curb the carbon dioxide (CO<sub>2</sub>) emissions by 52%. In comparison to the traditional route of Suez Canal, cost savings by using the (NSR) could be as large as about 4.7 million US dollars from a full round voyage between the certain ports. This may attract the maritime actors to make the concerning required investments. Global product price differences and variations in the energy market may affect the prospective use of Northern Sea Route. In present, the lack of icebreakers and a scanty fleet of standardized ice classed vessels may delay the early transit operations across the NSR.

This study aims to investigate the economic and environmental potential of Northern Sea Route over the Suez Canal for the transit shipping. Case study is used to compare the key shipping cost components and CO<sub>2</sub> emissions, for the full round voyage of an LNG carrier traversing the Northern Sea Route and the Suez Canal between Europe and Asia. The total savings made in respect of cost and CO<sub>2</sub> emissions by using the Northern Sea Route are derived, by citing to the most recent interviews of arctic shipping experts and existing literature. A sensitivity analysis is conducted to assess the impact of key cost components on the overall shipping cost picture.

**Key Words:** Northern Sea Route, Suez Canal, Global warming, Carbon dioxide, Economic potential, Sensitivity analysis, Ice-classed vessel

## **Acknowledgements**

I dedicate this work to my family and friends who were always supporting me in every stage of my life

## **Preface**

This thesis report is a mandatory requirement for the Master of Science in Management program at Vestfold University College, Norway.

This report is not only for those who are working in maritime sector but it purveys useful information to even those who do not have maritime background. This interesting topic has grabbed the international attention over the recent years. The author conducted a comparative case study and proved that the Northern Sea Route is a cost efficient passage.

I would like to thanks my supervisor Halvor Schøyen, Associate professor at the Faculty of Technology and Maritime Sciences. From the beginning to the end, his constructive comments and suggestions made possible the accomplishment of this study.

I want to specially thank Henrik Faclk from Tschudi Shipping Company, who played a key role in the completion of this study. My special thanks to Willy Østreng, Roar Oslen, Gard Insurance Company, Skuld insurance company, Hoegh LNG, and Dynagas Ltd. They all contributed by providing the primary data for this study.

I am grateful to my big brother who has always been supporting and giving me motivation.

Vesrfold, November 2013

Zeeshan

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## **List of Acronyms**

NES:	North East Passage
NSR:	Northern Sea Route
NWP:	North Western Passage
TTP:	Transpolar Passage
LNG:	liquefied Natural Gas
GHG:	Green House Gas
CO <sub>2</sub> :	Carbon dioxide
EIA:	Energy Information Administration
AMSA:	Arctic Marine Shipping Assessment
DFDE:	Dual Fuel Diesel Electric Propulsion
IMO:	International Maritime Organization
FOE:	Fuel Oil Equivalent
BOG:	Boil off Gas
GCU:	Gas Combustion Unit

## **List of Units**

Tcf:	Trillion Cubic Feet
MT:	Metric Ton
MMBtu/MMBtu:	Million British Thermal Units
NM:	Nautical Mile

# 1.Introduction

## 1.1 Background

Since the ancient times the mobility of merchandise, folks and knowledge has been the core feature of the human civilizations. Today the human being is highly dependent on the transportation systems to perform extensive daily work operations, moving commodities from the place of origin to the point of consumption (Rodrigue, Comtois, & Slack, 2009)

Over the centuries sea transportation has played an indispensable role in the world's economic growth. Shipping provides the transport mode required to accelerate the economic growth. With the passage of time, advancements within maritime industry have led to globalization of world economy and gain lower transportation costs (Stopford, 2009).

Shipping lanes or maritime transport routes are a substantial strategic part of the maritime transport system. A maritime route is a passage over the sea that connects the two different geographical points, where the land transport is impaired to purvey an efficient and effective transport mean. Maritime routes follow a defined way of voyage and are subject to certain geographical, natural and political limitations (Rodrigue et al., 2009).

Today the sea borne trade between Europe and Far East Asia is carried through the traditional route of Suez Canal and Cape of Good Hope, but this research is intended to investigate mainly the Suez Canal route and its emerging alternate the North East Passage (NSR). Suez Canal is chosen because it is a significant part of several existing logistic arrangements, which support the trade activities between Europe and Asia, and the Northern Sea Route for being a proven functioning passage and offering a minimum sailing distance to Asia (Schøyen & Bråthen, 2010).

Suez Canal is a 119 miles long artificial waterway that has served the global trade over the last one and half century. The canal connects the Mediterranean Sea with the Gulf of Suez providing navigational access to Far East Asian countries. Today about 50% of the total traffic of the canal is covered by container vessels whereas the LNG ships count approximately 6% of the entire traffic volume. The Suez Canal can handle up to 25000 ships per year and the current traffic is

on average 20000 vessels per year, which is 15 percent of the entire maritime trade (SCA, 2013; Rodrigue et al., 2009).

The dream to find alternative shortcut sea ways to Asia was eventually realized when in 1879 Finnish-Swedish explorer Adolf Erik Nordenskiöld conquered the Northern Sea Route, sailing from Europe to the Bering strait (Carbonnier, 2013). The maritime route from west of the Kola Peninsula through the Bering Strait in the east along the coast of Siberia has been named as the Northern sea Route (NSR). Nordenskiöld's voyage was a huge achievement though, but the treacherous ice conditions are still an obstacle for the commercial shipping on the route (Ragner, 2000; Schøyen & Bråthen, 2010).

However, over the course of time the thawing Sea ice triggered by global warming has opened up a new horizon for the environment friendly and fuel-efficient route of NSR between Europe and Far East Asia, cutting the distance by 40% between Rotterdam and Yokohama in comparison to the traditional royal route of Suez Canal (Liu & Kronbak, 2010). Until the late 1970s the route was mainly used as an internal transport passage by Russia since its commencement in 1935, and the highest cargo volume of around 7 million metric tons was recorded in 1987 (Schøyen & Bråthen, 2010).

Over the last three decades there has been a considerable decline in the amount, area and thickness of the sea ice cap in the northern hemisphere, resulting in a longer navigational season of 129 days in 2006 which was just 84 days back in 1979 (Schøyen & Bråthen, 2010). The declining pattern of the summer sea ice will lead to an ice-free arctic ocean during the summer months by the end of this century (Ragner, 2000). However, some researchers believe that the blue arctic in summer could appear even earlier between 2026 and 2046 (Ho, 2010).

The stated climatic changes in the arctic could lead to the substantial exploration and maritime operations in the region. The feasibility of NSR is evident as last year (2012) some more than 45 vessels traversed the NSR and this figure shows a tenfold growth in the route traffic since 2010 (Carbonnier, 2013). Being a shortcut between Asia and Europe the NSR could prove an environment friendly and fuel-efficient trade passage, as the shorter sailing distances lead to fuel savings and reduce CO<sub>2</sub> emissions (Schøyen & Bråthen, 201; Kitagawa, 2008).

This research intends to investigate the economic and environmental saving potential

## **1.2 The Research Problem**

The prediction models of the sea ice, forecast that the trend of ice thaw would continue and even at a greater pace in the future. The retreatment of ice presents new developments and opportunities for the transarctic shipping, but this situation also poses a threat too to the environment in the meanwhile (Liu & Kronbak, 2010).

Due to the growing population and higher income, levels the world energy need has increased rapidly, and in Asia, particularly the demand will rise more in the coming years than anywhere else will in the world. The liquefied natural gas is a significant mean to meet the growing thirst of energy. Japan is already the world's largest consumer of LNG and is planning to import more gas in the short run after the nuclear incidents (Kumar et al., 2011).

Experts say that the discovery of shale gas in United States has given new turns to the global gas market, and the world's northern most gas terminal of Hammerfest, Norway, which was built with the intention to export most of its output to the US, now needs to search for the new markets (Nilsen, 2012).

The dramatic thaw of polar ice cap, proven efficiency of the Northern Sea Route, growing environmental concerns on Green House Gas (GHG) emissions and major transitions in the world energy map are some of the vital factors that stimulate the interest to study the Northern Sea Route as an alternate to Suez Canal.

The phenomenon described above creates a niche market for the northern gas terminal that they can sell their LNG production in the Asian market using the shortcut route of NSR. The study of NSR has various dimensions though, but this report will mainly consider the economic and environmental aspects of the route specifically for LNG carriers.

## **1.3 The Research Focus**

Multiple research studies are conducted to compare the economic feasibility of the Northern Sea Route as a competitor to the Suez Canal. Most of these studies are mainly written for the container-shipping segment and none of them discusses the LNG shipping segment.

The focus of this report is to analyze the commercial and environmental potential of the Northern Sea Route in context of LNG shipping. This study investigates the feasibility to achieve the better environmental sustainability in terms of GHG emissions and to gain the lower voyage costs for the LNG carriers sailing between Europe and Asia using the NSR. In addition, this study explores that how the prospective transitions in the energy market may affect the use of Northern Sea Route in the coming years.

A case study is conducted to assess the economic potential of NSR for the LNG transportation. The cost incurred on a voyage taking the LNG cargo from Hammerfest, Norway to the port of Tobata, Japan via NSR is compared with the cost spent on the trip through the Suez Canal using the same loading and discharging ports. In addition, the CO<sub>2</sub> emissions from both alternate passages are assessed to determine the sustainability factor. A sensitivity analysis is also performed to analyze the impact of variations in the key cost components on the overall shipping cost picture. The case study is elaborated in the chapter five of this report.

#### **1.4 The Research Questions and Objectives**

This report aims to provide knowledge to the concerning actors in the maritime sector about the potential of the Northern Sea Route over the Suez Canal in respect of cost efficiency and CO<sub>2</sub> emissions.

Currently there are many uncertainties regarding the future of the NSR such as the dynamic arctic climate, higher NSR tariff, political obstacles, and lack of required infrastructure. Because of the risks and challenges involved in the use of NSR the actors in the shipping industry seems reluctant to invest in the short run. The report however attempts to unveil the economic and environmental scope of the NSR for the LNG shipping segment and it may help the relevant bodies in decision-making.

In order to serve the above-mentioned objectives the following research question is answered;

*How much is the economic potential of using the Northern Sea Route as an alternate to the Suez Canal for LNG transportation between Europe and Asia and how the NSR can assist to gain the environmental sustainability in respect of CO<sub>2</sub> emissions?*

Taking the research problem and question of this study into account following supplementary question are formed:

- 1.How do the transitions in the energy market including the shale gas revolution affect the potential use of NSR and exports from northern gas plant?
- 2.How would any variation in the key shipping cost components influence the efficiency of the Northern Sea Route as an alternate to the Suez Canal?
- 3.What is the scope of Northern Sea Route for LNG shipping?

In order to answer the main research question and sub questions of this study, literature is reviewed and interviews are conducted. Most of the cost calculations are based on the primary data obtained from the shipping experts and maritime professionals because the existing literature is impaired to provide with the specific information to correctly answer the research questions.

### **1.5 The Structure of the Thesis**

This thesis report contains total five chapters. The first chapter presents the background of the study, the research problem and objective, and the research question. The second chapter reviews the relevant existing literature. In the third chapter, the research methodology that is pursued to answer the research questions is demonstrated. Fourth chapter includes a comparison of the Northern Sea Route and Suez Canal and the research findings of this study. The chapter five involves a discussion about the research findings. The sixth chapter closes with the conclusion of this study and presents future research directions.



## **2. Theoretical Framework**

The research problem and research question is defined in the previous chapter. Based on the research problem and questions of this study, this section aims to develop a theoretical framework for this research study. The literature and theories concerning to the research problem of this report are presented here to provide a review about the different aspects of this research.

### **2.1 Arctic Climate Change**

In this section, the objective is to give an overview about the climate changes in the arctic region, and to see that how the climate changes open new possibilities. The arctic shipping is mainly dependent on the ice melt, and an ice-free arctic can stimulate the shipping activities by forming new shipping route.

Arctic is the region on earth that is facing the most drastic climatic changes. Climate prediction models depict that in comparison to the rest of the world, temperature level in arctic is increasing at a double rate, and this trend is likely to accelerate in the coming years. Over the past five decades, the ice thickness in the arctic has reduced considerably, and the summer ice extent is decreasing at 6.2 percent per every decade (AMSA, 2009).

The following satellite picture captured in September 2007 and 2008 and it demonstrates that how the soaring temperatures in the arctic leading to more ice-free areas. In relation to 2007 the extent of ice free area increased in 2008 (See figure 2.1).

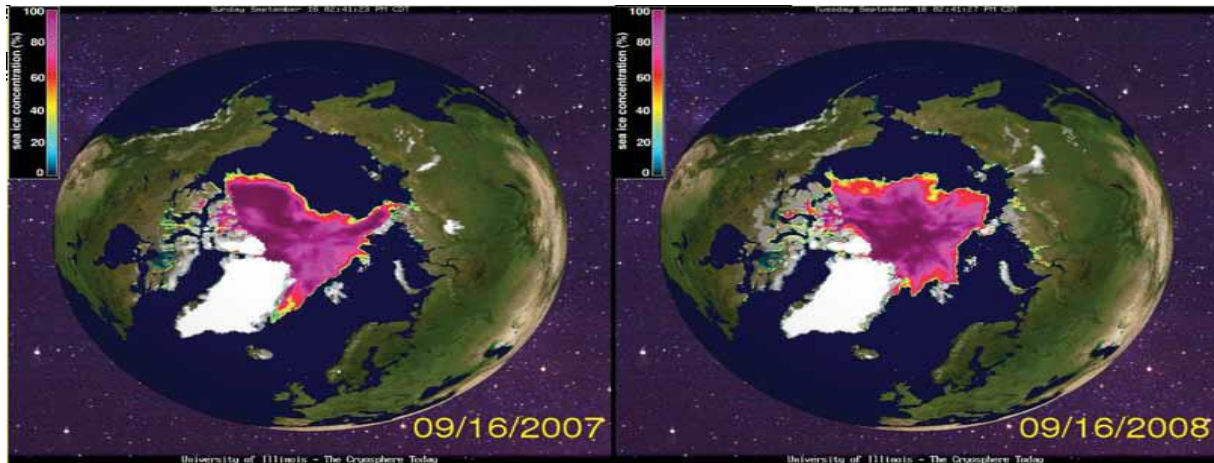


Figure 2.1: Satellite image of summer ice covers in 2007 and 2008 (AMSA, 2009)

The declining pattern of the summer sea ice will lead to an ice-free arctic ocean during the summer months by the end of this century (Ragner, 2000). However, some researchers believe that the blue arctic in summer could appear even earlier between 2026 and 2046 (Ho, 2010). It is important to note that all the prediction models mainly inform about the summer ice reduction not the decrease in winter ice.

The decline of sea ice increases the opportunities for exploration of hydrocarbons from the region and it would remarkably accelerate the shipping activities in the region by introducing new transit shipping lanes (AMSA, 2009).

The following section elaborates that what are the new shipping routes are likely to emerge because of ice melt.

## 2.2 Arctic Shipping Routes

The purpose of this section is to highlight the possible shipping routes that may become functional after the ice melt from the arctic region. Due to ice, some of these routes may take several decades to allow the transit shipping, and in present, only the Northern Sea Route is navigable during the summer months. Therefore, this study pays main attention on the Northern Sea Route (NSR) and investigates the economic and environmental importance of this route as an alternate to the Suez Canal.

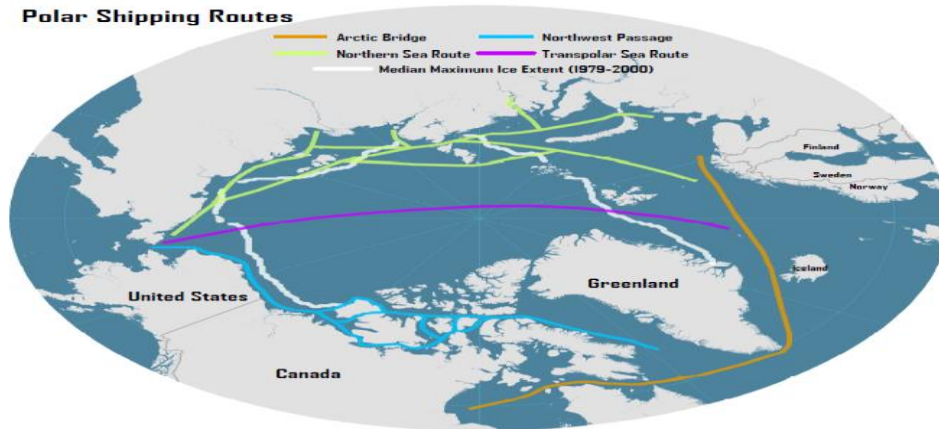


Figure 2.2: Arctic shipping routes (Rodrigue et al., 2009)

For decades, shipping activities are carried out mainly within the territories of Russian arctic and intra arctic sailing was the mean to move out hydrocarbons from the region or to support the military objectives. The domestic shipping was used to transport the minerals and hydrocarbons from the region at a huge level. However, the receding ice over the arctic has now opened up new lanes of trade, making the transarctic shipping possible. As the trans-arctic shipping sufficiently curtails the distance between some of the major trade hubs in the world and thus reduces the CO<sub>2</sub> emissions. That is why transarctic shipping is the part of the study (Kitagawa 2008).

Three major shipping lanes come in to existence to support the transarctic transportation of cargo as a result to the ice melt. First, the Northeast Passage or Northern sea route is a shipping lane that connects the Atlantic Ocean to the Pacific Ocean along the arctic coast of Russia. Second, there is another significant route the North Western Passage (NWP), which presents relatively a shortcut route than through the Panama to North America, follows the Canadian archipelago to the Atlantic Ocean. Third, the route that joints Norway and Russia to the Canadian port of Churchill is called the Arctic Bridge. Finally, comes an assumed direct link that crosses the center of the Arctic and forms a route between Atlantic Ocean and Barents Sea is known as Transpolar Sea route (Rodrigue et al., 2009).

The northern sea route is a proven developed trans-arctic passage today and the distance saving by the route is far higher than by the NWP. The route contains a better infrastructure that is not

provided by NWP and it is most likely that the ice will melt earlier along the NSR in comparison to NWP. Trade volume from the NSR is nearly two million that is predicted to reach over 40mn by the 2020. The Arctic Marine Shipping Assessment (AMSA) report 2009 forecasts that due to uncertainty the NWP is not likely to become a potential shipping route by the end of this decade (AMSA, 2009). This thesis however, mainly focuses on the Northern Sea Route and the Suez Canal route.

### **2.3 The Northern Sea Route and Suez Canal Route**

As described earlier in the first chapter that currently the trade between Europe and Asia is carried through the Suez Canal route. This section intends to provide a comparative overview of the existing Suez Canal route and the emerging alternate the Northern Sea Route.

Suez Canal is a 119 miles long artificial waterway that has served the global trade over the last one and half century. The canal connects the Mediterranean Sea with the Gulf of Suez providing navigational access to Far East Asian countries. Today about 50% of the total traffic of the canal is covered by container vessels whereas the LNG ships count approximately 6% of the entire traffic volume. The Suez Canal can handle up to 25000 ships per year and the current traffic is on average 20000 vessels per year, which is 15 percent of the entire maritime trade (SCA, 2013; Rodrigue et al., 2009).

As discussed in the previous section that because of ice melt a new route is emerged namely the Northern Sea Route of NSR.

The NSR is the seaway that connects the Atlantic and Pacific oceans and follows the northern coast of Russia. It is necessary to mention here that northern sea route is not a specific or fixed shipping lane rather it is an arrangement of several different shipping routes. The passage is spread over around 2200 to 2900 nautical miles of icy water and traverse different straits and seas such as the Kara Sea, the Laptev Sea, the East Siberian Sea, and the Chukchi Sea (Østreng

et al., 2013)

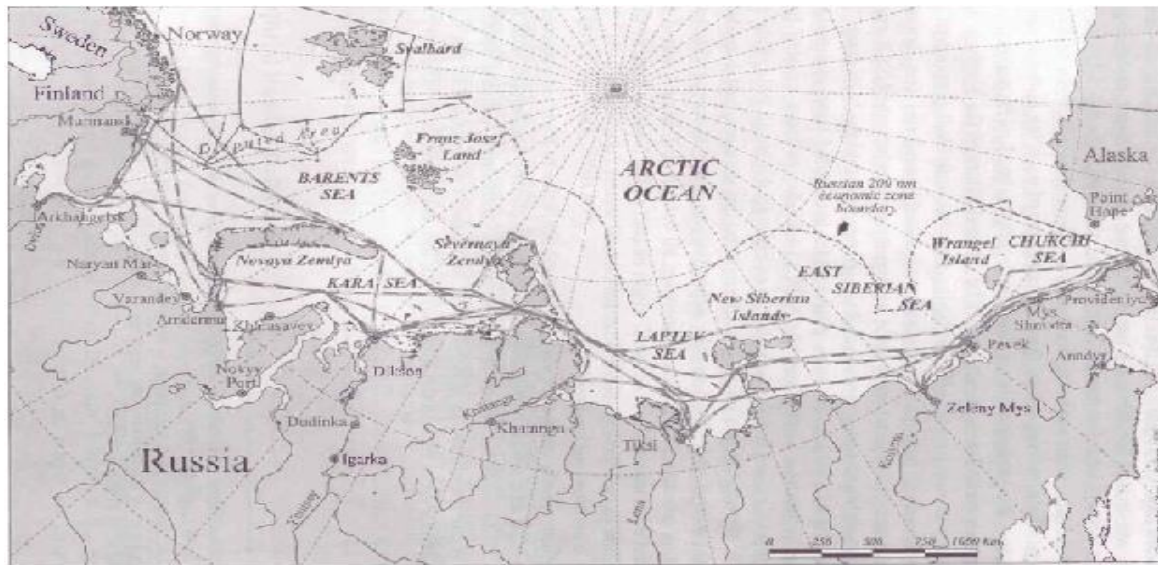


Figure 2.3: The Northern Sea Route (Østrem et al., 2013)

As compared to Suez Canal the NSR is particularly characterized with considerable distance saving of nearly 40% between Rotterdam and Yokohama (Liu & Kronbak, 2010). The sailing on the route demands the mandatory assistance of icebreakers.

An LNG tanker navigating through the NSR curtails substantial benefits over the traditional route of Suez canal such as fuel saving, increased number of voyages results in multiple gas deliveries, saving from LNG evaporation and lower amount of CO<sub>2</sub> emissions et cetera (Gazprom, 2012).

The following table shows the distance to some of the ports located in Asia and Europe using the NSR in relation to the Suez Canal. Figures derived from different sources vividly depict that NSR is the most attractive option on the trade route between Europe and Asia.

<b>Maritime Route</b>	<b>Northern Sea Route</b>	<b>Suez Canal</b>
Hammerfest_ Tobata	6 132	12 144
London _Yokohama	6 600	11 400
Rotterdam_ Shanghai	8 528	10 556

Table 2.1: Distance of alternative maritime routes for ports in Pacific and Atlantic oceans in nautical miles (1nm=1.852km) adapted from (Ostren, 2013; Falck, 2013; Christensen, 2009)

The researcher of this study had a chance to interview Willy Ostren about the comparative scope of the NSR and Suez Canal. Willy Ostren headed the International Northern Sea Route program (INSROP) and currently is serving as a senior researcher and the president of Norwegian Scientific Academy for Polar Research. The interview held in down town Oslo in October 2013. During the interview, some interesting points were unveiled about the Northern Sea Route and Suez Canal. A transcript of this interview with Willy Ostren related to this section is presented here to deliver a professional viewpoint to the readers and to form a theoretical base for the research questions of this study. For the details of the interview questions and the concerning answers (See Appendix).

What would you say about the potential of the Northern Sea route as an alternate to the Suez Canal, for the LNG shipping?

*“That’s a big question, but in the light of accelerating sea ice melting there is no doubt that between northern European , northern Asia and northern American countries the northern sea route or the north east passage has a huge potential because its shortcut between the most economically developed parts of the world. Thus in that respect, if the sea ice is removed by global warming as it is, and even this is accelerating, and if the sea ice that is left is weekend then of course the potential of the suit is enormous. If you go London to Yokohama in Japan, you save 40 % of the trade distance in comparison with going through the Suez Canal that is 6 600 nautical miles through the NSR and 11 400 nm through the Suez Canal. It goes around same, when you have set a saving in distance it can be transformed in to savings in sailing days and we*

*know that there are multiple examples that 15 up to 18 days can be saved by using the northern sea route instead of the Suez Canal. So in general the very fact this is the shortcut geographically speaking and the fact that the ice both retreating throughout the north pole and the marginal seas are getting ice free and the remaining ice getting weaker, then of course you can use the passage with existing shipping technology. What you will have to do is all the investments to build up a fleet that can cope with ice-infested waters because even if it is free there will always be icebergs and drifting in the sailing lanes of the ship. Consequently, you will need to have ice-strengthened hull on the freighters and there would need to have icebreakers assistance.*

*So that's the general answer to this question and when it comes to LNG of course there is need for LNG in multiple Asian countries, such as Japan the biggest LNG consumer in the world, China, South Korea their needs are really important in this respect. Not least, they have all the experience that going through the traditional sea routes in southern waters means that they are subjective to piracy, political conflicts in the Suez Canal, in the Panama Canal. Consequently, in order to really have secure deliveries of LNG which then support the idea of going north which is the only place with no piracy and I would argue that where there are no political risks of deliveries being stopped. So as seen from a broader perspective, mean in political and criminal perspective the northern sea route or the Northeast Passage. Because there is difference between NSR and North East Passage, the Northern Sea Route extends from Novaya Zemlya to the Bering Strait whereas the North East Passage also includes the Barents Sea that makes the North East Passage a two state passage. We usually think that North East Passage is Russian route, to a large extent it is, but little Norway also has to say in this respect. I would say in general that this route has a huge potential to compensate for some of the problems such as political problems we face in southern latitudes. In the post-world war periods Suez canal was closed for several months twice and forcing international shipping to go around Africa which adds extremely to the costs of energy and of course the poor countries, the developing countries are suffering the most in that respect. So again, going north has a huge potential if ice melting will continue, so that ice is getting weaker and ice is disappearing. The NSR is a kind of alternative to compensate for political problems in the Middle East, for political problems outside of Somalia. Political problems in the South China Sea you will avoid all these problems by using the NSR. There is huge momentum or motto for those who are in the need of LNG to develop a shipping fleet that*

*can operate in ice-infested waters. When I say ice infested waters it's because the ocean will freeze out in winter but of course then ice is weak and its thinner and it can be combated by the existing ice breaking technology, so even if you have ice this ocean has a huge potential given the melting'' (Østreng, 2013).*

Similarly, Henrik Faalk who is maritime professional in a Norway based arctic shipping company, during the personal interview that held in his office located in the outskirts of Oslo on 1<sup>st</sup> October 2013, he commented as following on the question about the potential scope of NSR;

The scope of Northern Sea Route as an alternate to the Suez Canal, in particular for LNG transportation:

*''The Northern Sea Route can open for new LNG projects in the far North, previously it was like finding a gold mine on the moon it did not help because the transportation will kill everything but today the transportation can be very competitive with alternative sources of supply. The distance from Mostar, Bergen to Yokohama is same as the distance from Arabian Gulf to Yokohama. Of course when you go from Arabian Gulf to Japan you are not crossing any canal, you do not pay any, and you need not to have any ice class vessel etc. Going through the NSR from Melkøya to Tobatta is exactly fifty percent quicker than sailing through the Suez Canal. It opens up a completely new market but what is particular for the LNG trade is that the investments are so huge that nobody starts an LNG plant unless they have the long-term contracts and Melkøya was established before the NSR was finished. Therefore, everything is sold out but of course they have already done two or three trips through this passage and they are saving 8 million dollars on one trip. In Sabeta, where the Russian company Novatek plans to establish an LNG plant for them the advantage is more better because they are five days close to the Far East market''*

*''It will only be of relevance for those who are contemplating to produce LNG up north, for the LNG coming out from the US in future it has absolutely no relevance. I think it is a game primarily for Russia. I often say that the freight will no longer kill the deal because of the northern sea route. Previously if you have LNG up north you were too far away from the consumption market but now you are very close to the market. So that's why investing a huge*



*amount in LNG plant of Yamal, with the 20 percent share of Chinese National Oil company (CNOOC) at the Sabeta port'' (Falck, 2013)*

Summing up from the above, we can say that the NSR is comparatively more efficient in terms of sailing distance and it compensates for the problems lie in the Suez Canal today. The NSR has a huge potential for the LNG shipment primarily from the northern hemisphere.

## **2.4 Comparative Economic Potential of Routes**

The routes can be discussed in various aspects but bearing the scope of this study in mind, this section aims to narrow down the research to the literature related to economic potential.

Several research studies are conducted to compare the economic aspects of transit shipping along the NSR and its other alternates. Some of the most relevant studies are reviewed here to provide the reader a glimpse of the existing work and to develop a better understanding of this research. Most of the studies mainly focus on the container shipping segment; however, in the following this report will give a brief overview of the studies related different shipping segments such as bulk, container and general cargo shipping.

Schøyen and Bråthen (2011) investigated the economic potential for the trans-arctic shipping of bulk cargo of iron ore and nitrogen fertilizers. The authors compared the CO<sub>2</sub> emissions from the bulk carriers navigating between Europe and Fareast Asia through the NSR, Suez Canal, and the Cape of Good Hope. This study ranked the NSR as 100% and the Suez Canal as 22% in terms of energy efficiency. The CO<sub>2</sub> emissions were 623 metric tons and 3893 metric tons for sailing through NSR and Suez Canal respectively. The per metric ton shipping cost of iron ore was calculated 39 and 37 US dollars for the shipping via the Suez Canal and NSR respectively. This study demonstrates that the reduced number of sailing days, fuel cost savings and lower CO<sub>2</sub> emissions are the main advantages of sailing through the Northern Sea Route in comparison to the Suez Canal(Schøyen & Bråthen, 2011).

Liu and Kronbak (2010) conducted an extensive economic feasibility analysis for the container shipping from Europe to Asia via the Northern Sea Route. The total annual cost was compared against the revenues to determine the commercial potential under the different scenarios. This study took into account a single container vessel sailing at annual basis, through the NSR during

the navigable period and via the Suez Canal during rest of the period. The study relies on the three major variables that are the NSR fees, the fuel cost, and the sailing period. Scenario analysis was performed to analyze that how the reduced NSR fees affect the total cost and revenue structure under the varying bunker prices. The calculations were made for different sailing periods such as the 3 months, 6 months, and 9 months. The bunker price was set as low bunker price (350\$/ton), medium bunker price (700\$/ton) and high bunker price (900\$/ton). The reduction in NSR fees was assumed as 50%, 85%, and 100%. This research figured out that due to the huge NSR fees, it is not economically feasible to carry profitable container shipping operations along the NSR, the lower the NSR fees, the higher the competitiveness of the NSR(Liu & Kronbak, 2010).

Østreng et al (2013) in their book ‘Shipping in Arctic Waters, presented an extensive economic comparison of different arctic routes, namely the Northern Sea Route, Northwest Passage (NWP), Transpolar Passage (TTP) and Suez Canal. Their study compared a general cargo ship with the same features as the Beluga Fraternity, which navigates between Yokohama-Hamburg via the NSR and through the Suez Canal. The icebreaker fee was not taken into account while making calculations, because it was assumed in the study that the NSR can be navigated without the icebreaker assistance in the future. The comparison concluded that the NSR is more attractive in terms of fuel savings that is nearly \$ 160300 and saving in sailing days, which is 11 days. Similarly, they compared the single trip of a container vessel navigating between Shanghai-Hamburg via the NSR and via Suez. It was revealed, that the NSR has potential to save \$ 6 06 000 in terms of fuel in relation to Suez; however, the saving in sailing time was estimated as only two days. The NWP and the TPP are not discussed by the researcher here as they are beyond the scope of this study(Østreng et al., 2013)

Summing up, the above research studies present the economic picture of the shipping through the NSR for the different shipping segments. The NSR fees, the ice conditions, and the bunker prices have been the critical factors in most of the studies, which influence the economic feasibility of the route.

## **2.5 Comparative Environmental Potential of Routes**

This section aims to explore that how the shipping routes play their role in ensuring the environmental sustainability in terms of carbon dioxide (CO<sub>2</sub>) emissions.

International Shipping Activities affect the environment and the society by emitting the harmful greenhouse gases such as carbon dioxides (CO<sub>2</sub>) nitrogen oxides (NO<sub>x</sub>), Sulphur oxides (SO<sub>x</sub>) and particulate matter (PM) et cetera. The research question of this study mainly pays on the CO<sub>2</sub> emissions (Østreng et al., 2013).

The sea transportation emits 1 billion tons of CO<sub>2</sub> annually which makes nearly 3 percent of the entire global emissions, and the Arctic emission of CO<sub>2</sub> from shipping appears as about 1 percent in 2004 (Østreng et al., 2013).

There is a direct relationship between the distance and fuel consumption, which means a longer distance, causes more fuel burning and eventually results in more emissions. (Schøyen & Bråthen, 2011) argue that the small sailing routes could prove environment friendly and the sustainable transportation systems may have a positive impact on the NSR for the transarctic shipment between Europe and Asia.

According to the investigation of (Schøyen & Bråthen, 2011) the Northern Sea Route appears as more environment friendly sailing route as an alternate to Suez Canal for the transit shipping between Europe and Asia. They found that a vessel sailing between Northern Norway and Northern China via the NSR reduces about 3 270 metric tons of CO<sub>2</sub> emissions in comparison to the shipping via the Suez Canal. They argued that the emission saving potential of the NSR is even higher for the vessels using LNG fuel.

This research however, compares the CO<sub>2</sub> emissions for the LNG vessel traversing the NSR and Suez Canal (See chapter Case Study).

After discussing the comparative analysis of the NSR and Suez Canal, the following section involves a discussion about the cargo of this study. The section studies the nature of LNG cargo, the demand, and supply of LNG, the shipping aspects of LNG cargo and the impact of shale gas on LNG. The purpose is to explore that how these mentioned factors affect the potential use of routes.

## 2.6 Liquefied Natural Gas (LNG)

According to research question of this study, this research mainly focus on the shipping of liquefied natural gas (LNG), before going into details on other aspects of this research it is better to understand the LNG product nature. This section briefly presents that how the LNG is made and what are the components of its value chain.

Natural gas is a composition of various gases such as methane, ethane, and propane. It may contain a tiny amount of nitrogen, oxygen, carbon dioxide etc. During the liquefaction process, non-methane components mainly the carbon dioxide and water are removed from the natural gas(Foss, 2012). The figure 2.4 depicts a typical composition of Natural gas.

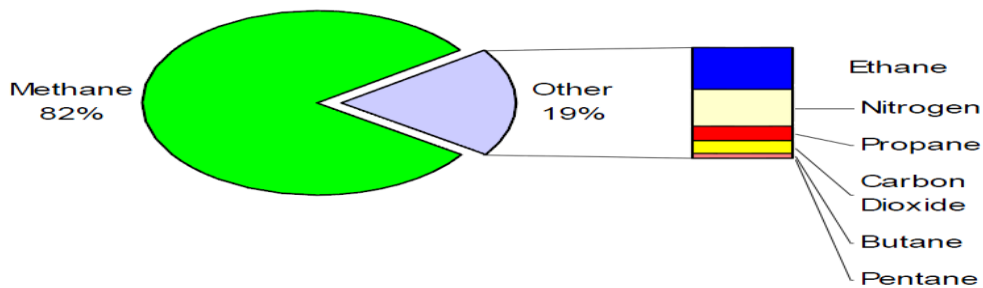


Figure 2.4: Composition of Natural gas (Foss, 2012)

Liquefied Natural Gas (LNG) is natural gas that is cooled until it condenses into liquid at about -161 degree Celsius and at atmospheric pressure. It is an odorless, colorless, and non-toxic gas. The liquefaction process reduces the gas volume by 600 times and thus makes it feasible to transport large quantities of LNG to the far off places in the world where the pipeline transportation mode is expensive in this respect. Figure 2.5 presents a typical composition of LNG that consists of 95 % of methane gas and rest of the 5% is formed by ethane, propane butane, and nitrogen. It is worth mention here that the composition of LNG varies across the different continents of the world and that eventually affects the price of LNG

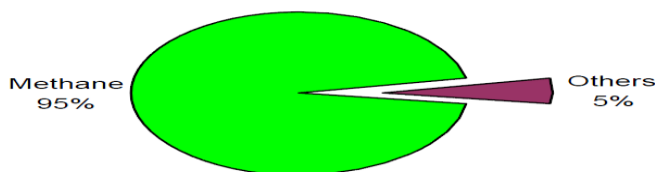


Figure 2.5: LNG composition (Foss, 2012)

### 2.6.1 LNG Value Chain

The LNG value chain consists of four stages namely exploration, liquefaction, shipping, and storage and regasification (See figure 2.6). The shipment of gas in LNG form is economical, where the transportation distance is more than 700 miles or 2200 miles for the offshore pipelines and onshore pipelines respectively(Foss, 2012). The price of LNG ranges from \$2.5 per MMBtu to \$5.5 per MMBtu depending on the transportation cost. This study only investigates the shipping part of the LNG value chain.

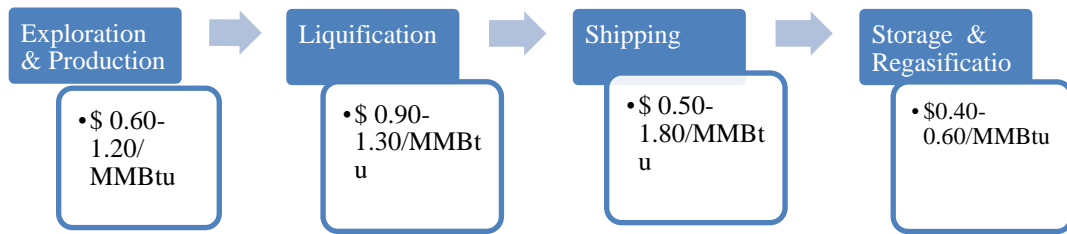


Figure 2.6: LNG Value Chain based on (Foss, 2012)

### 2.6.2 LNG Demand and Supply

This section provides an overview about the global consumption and production trends of the Liquefied Natural Gas (LNG), it seems significant to look at these market forces of LNG that are likely to affect the prospective use of Northern Sea Route in the coming years.

Liquefied Natural Gas (LNG) is a major source to meet the growing energy needs. Global LNG demand has increased rapidly and Asia in particular appears as the largest consumer of LNG. In the world's energy-mix, the share of the gas is expected to reach 25% by the end of next couple of decades. The LNG demand is projected to rise about 5% to 6% per annum. Experts forecast that by the 2030 the global LNG need would be double in comparison to the current demand level (EY, 2013 b).

Japan, South Korea, and Taiwan are the world's largest consumer of LNG and are predicted to hold with this position in the future. China and India also would need more LNG in the future due to their domestic needs (EY, 2013 b). The following figure 2.7 demonstrates the past and future trends in the demand of LNG. In the figure, it is clear that the LNG demand would soar in

the future and Asia forms a larger share of the total demands. In the figure 2.7 JKT denotes the three largest LNG consumers namely Japan, Korea and Taiwan.

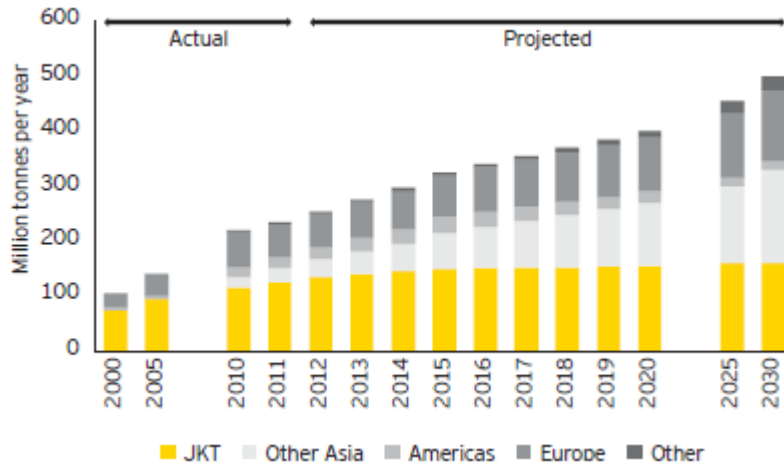


Figure 2.7: Global LNG demand (EY, 2013 b)

Fukushima incident in Japan and its impact on NSR:

*According to (Østreng, 2013) “we can foresee both US and Japan shipping will go to Japan and Japan is an ally of US. The Yokohama incident may increase the internal demand of energy and US may be the one supplier for that. Norway and Russia may also the eastward trade of the LNG will increase in the future not only due to Fukushima but also to the increasing needs of China in its process of increasing growth. Therefore, Yokohama will be one aspect will be one element in this respect. And of course Japan being a largest consumer of LNG in the world will now probably rely less and less on nuclear energy and more and more LNG but that’s is an aspect in this respect” (Østreng, 2013).*

Algeria, Indonesia, and Malaysia were the main supplier of LNG until recently but over the next few years Australia and Qatar are predicted to appear on the map with the huge LNG supplies. However, there is huge competition is expected in the supply market. Future LNG projects from Russia and North America are also predicted to sell their output in the Asian market to avail the high prices there (EY, 2013 b), however this situation may not continue longer and it may bring down the price even in the Asia market.

*According to (Falck, 2013) “today the Far East market is paying premium on this particular product. If that will maintain in the future, as I can remember they are paying \$15 per million btu in Japan, on the EU continent its about \$10 per Million British Thermal Units (MMBtu), and in USA you have around \$7. In my opinion, such an imbalance in the market cannot be sustained because now everybody wants to sell to Japan. The price of the product is also a determining factor for the prospective use of NSR. For example previously we were getting 20 percent more on the iron ore product from the Chinese market as compared to the EU continent and of course 50 percent shorter route to the market paying 20 percent more it becomes extremely interesting”*

Summing up above it seems that the LNG demand is likely to increase in Asia and new gas suppliers will compete to avail the high prices in the Asian market and this competition will ultimately balance the regional price differences of LNG. The Northern Sea Route will play a significant role and give a competitive advantage to the Russian supplies of LNG.

## **2.7 Arctic Hydrocarbon Reserves**

This section provides an overview about the importance of arctic region and looks briefly at the two arctic states that may have a strong impact on the future use of Northern Sea Route. In future large cargo deliveries for the Northern Sea Route are expected to come from arctic region and therefore, it seems necessary to present a picture of this area.

The Arctic region holds the abundance of oil and gas reserves. According to statistics, 25 percent of world’s total undiscovered hydrocarbons are found in the arctic area. The assessment report by US geological survey in 2008 indicates that the arctic region contains 90 billion barrel of oil reserves and 1,669 trillion cubic feet of natural gas (EY, 2013).

### **2.7.1 Norway**

Norway is one of the world’s largest producers of oil and gas products. It has 21 trillion cubic feet (TCF) of gas reserves as of 2012 (EIA, 2012). Since 1981 the country has attracted many international and domestic companies which are engaged in exploration and production activities on the Norwegian continental shelf and Russian part of Barents Sea (Norheim, 2010). In spite of

some political and climatic challenges, the company intends to derive one million of oil equivalent over the next decade, expanding its drilling activities further in Skrugard and Havis gas fields. It is predicted that the LNG vessel operations from northern Norway to the rest of the world will steadily accelerate (Brigham, 2008). Currently, Norway is running the world's northern most LNG plant in Hammerfest and export its output to Spain and North America.

### **2.7.2 Russia**

Russia is the world leader in gas exports that is 7.3 trillion cubic feet (Tcf) and characterized as the only arctic state with a highly developed arctic infrastructure. Gazprom and Rosneft are the only companies who have the permission for exploration activities in the Okhotsk, Kara and Barents seas. Gazprom the national gas company is running vast extraction activities in Yamburg, Urengoy and Medvezh'ye gas fields. Currently there are two mega projects are also under consideration in the Yamal peninsula and Shtokman in the Russian arctic basin with the mutual efforts of Norwegian Russian and French companies. With each having 16 trillion m<sup>3</sup> and 3.8 trillion m<sup>3</sup> of gas reserves respectively (Harsem et al., 2011).

## **2.8 Shale Gas Revolution and LNG**

Norway exports the LNG to United States and Spain, but due to the invention of shale gas, experts say that USA may reduce its LNG imports from Norway. This section intends to define the shale gas and its possible impact on Norwegian LNG exports from Hammerfest. This part also investigates the impact of shale gas revolution on the potential use of NSR.

Shale gas is a natural gas that is found in the shale rocks. In comparison to other fuels, shale gas is a cheap fuel. The extraction of the shale gas is considerably difficult process that demands huge investments and latest technology. In order to release the trapped hydrocarbons from the shale rock, a sophisticated process is followed that involves the injection of sand, water and chemicals in to the shale rock (Dreyer & Stang, 2013).

Currently, the USA is the main producer of shale gas in the world. Since its boom in 2007, shale gas reduced the American imports from 16.5% in 2007 to 11% in 2010. Before the discovery of shale gas, the USA constructed the required infrastructure for the LNG imports but now the shale gas has remarkably transformed the natural gas market. Consequently, the USA may export natural gas to other parts of the world mainly to Asia (Dreyer & Stang, 2013).



Gunnar Sander according to Nilsen, (2012) explained that the revolution of shale gas has affected the gas market, and Norway may have to look for new customers to sale its output.

The researcher of this study put the following question to Willy Østreng, (2013);

How would you comment about the discovery of shale gas in United States and its possible impact on the use of NSR, and how do you see the future of Norwegian gas exports from Snohvit gas terminal, in this context?

Østreng, (2013)

*“Well, United States is in the process of getting self-sufficient with gas and this something absolutely brand new, one of the biggest consumers of LNG and gas is going to become self-sufficient. That of course will alter the geopolitics of energy in the world and in the light of above answer US in next five years’ time or so will not be that interested as seen a receiving country of oil and gas through the NSR and through the Arctic because it’s getting self-sufficient. We may foresee the possibility that the NSR, which is being considered until very recently as a supply route to the east coast of US may be a supply route from the east coast of US to the Asia.*

*When it comes to the Snohvit, it cannot no longer sell its gas to the US, US is no longer interested in arctic gas as it used to be. Norway therefore, will have to try to find new customers in continental Europe, which I think they will use the Northern maritime corridor that extends from the White Sea to the continental Europe. We saw it is established in 2002 as a kind of supplement in ice free waters to the NSR. So now, you have established two legs of a continuous route from continental Europe to up north to the Barents Sea and the White Sea that continues along the Siberian coast to the pacific. You do not have a northern pacific corridor, in the pacific. Then you will have a hemispheric transportation route that encircles a whole of Eurasian continents, two continents with shipping routes is a something brand new in this respect. I predict that the US may use the NSR in the future for selling its shale gas to Asian countries through the NSR. Norwegian gas, Russian oil from the Barents Sea and White Sea, and the Pechora Sea et cetera will not go to the US because it is much more costly than the shale gas. However, at the same time you have a strengthened focus of the global warming, the IPCC now in their last report claim that the global warming is manmade. No doubt, that the shale gas production is not very environmentally clean production. Therefore, we may even see a growing*

*movement internationally to stop the shale gas production if they succeeded, as we have already seen that some European countries have banned on the shale gas production. Other countries do have shale gas also for instance China but they lack the technology to produce it. Indeed, we are now to a certain extent caught in the middle of two globally very important issues, on one hand the production of shale gas which is very polluting and on the other hand a need to stop the global warming. That is part of the revolution of shale gas that it may cause political movements to stop it. At the same time, if we see from the US point of view this is a high priority in national interest in national interest to be self-sufficient with gas, because it has long history of being vulnerable to the turmoil of the Middle East, which has been the main supplier of oil and gas to the US. Now when the opportunity to be self-sufficient they are not likely to reverse that and be dependent again for the deliveries of oil and gas from the other parts of the world. I foresee a kind of political clash between the production of polluting oil and gas and the need to stop the manmade global warming. It should be said that the shale gas evolution is beginning, and it is hard to say about all possible ramifications. Shale gas will produce changes in international economy, international security; it will and may affect the arctic and the NSR. I will point out the NSR use as delivery route to the US that will not happen probably but it may be used as delivery route from the US to the Asia at least to Japan, South Korea and Taiwan, which are allies to the US. Nevertheless, politics will all the time be a part of equation'' (Østreng, 2013).*

## **2.9 LNG Shipping**

From the LNG value chain defined earlier in this chapter, this study mainly explores the shipping part of the value chain and makes a comparative analysis of shipping cost and vessel CO<sub>2</sub> emissions. The purpose of this section is to highlight the specialized requirements for the ships that intend to cross through the Northern Sea Route, as this study compares the LNG shipping cost it is essential to have a look over the technical aspects of the vessels.

As it is described above that for the longer distances, LNG carriers purvey a cheaper mode for transportation in relation to the pipeline mode. LNG vessels are specifically designed tanker ships used for the sea transportation of gas over the longer routes. The Membrane and Spherical are two main designs widely being used in LNG vessels. These vessels are equipped with highly sophisticated technology to ensure the safe and effective movement of cargo (Foss, 2012).

Ragner (2008) states that the navigation through the NSR requires special ice-classed vessels so they could withstand under the harsh weather conditions. An ice-classed vessel contains the more strengthened hull and structural support. Similarly in order to prevent the ballast water from freezing some warming systems and increased number of watertight bulk heads are installed in the ice-classed ships. In addition, there are also specific rules for the rudder and propeller design erected in ice classed ships (Liu & Kronbak, 2010).

Over the span of time, authorities have introduced firm and unified rules and standards for the vessels built with the arctic sailing purpose. The examples of such rules are Finnish-Swedish Ice Class Rules, IACS Polar Class Requirements, and Winterization by RINA and Lloyd's register (Brigham, 2008).

During the last decade, there have been considerable technological developments in the ice classed LNG carriers, which have raised the ice breaking efficiency and reduced the hull ice resistance. The assistance of icebreakers is also mandatory for the vessels traversing the NSR according to the Russian regulations for NSR navigation (Tustin, n.d).

The following section further narrows down the study, and focuses on the first ever LNG transit voyage that was conducted between Northern Europe and North East Asia.

### **2.9.1 The Pioneer LNG Transit via NSR**

Through the Suez Canal, a great number of LNG carriers navigate each year, but via the NSR, only few LNG vessels have sailed so far. In this section, the purpose is to provide an overview about the first ever LNG carrier 'Ob River' that traversed the Northern Sea Route in 2012. The section also quotes the interview of the operator of the vessel Ob River, the interview was conducted in October 2013. The interview provides the most recent information about the shipping through the NSR and uncovers the challenges and advantages of using the Northern Sea Route over the Suez Canal.

The ice-classed LNG carrier Ob River is the first ever vessel that completed her pioneer voyage between Europe and Asia through the NSR in 2012. The Ob River is a winterized membrane type LNG carrier built in 2007 with the 1A ice class standard and has the capacity to carry 147 500 cubic meters of LNG.

Russian gas company Gazprom chartered the Ob River from its Greek operator Dynagas Ltd, in early November last year the vessel loaded the LNG cargo at the Melkoya gas plant in Hammerfest, Norway and traversed the NSR with the assistance of two icebreakers, and delivered the cargo at the regasification plants at the port of Tobata, Japan in December. The same vessel also made a trial voyage on ballast a month before making the laden voyage (Hine, 2012). The historic voyage of Ob River reduced 20 days of sailing between Tobata and Hammerfest by navigating through the NSR, sailing through the Suez Canal in comparison takes around 40 days between the same ports (Wainwright, 2012). The figure 2.8 demonstrates the distance between Hammerfest, Norway and Tobata, Japan is shorter via the NSR and longer via the Suez Canal.

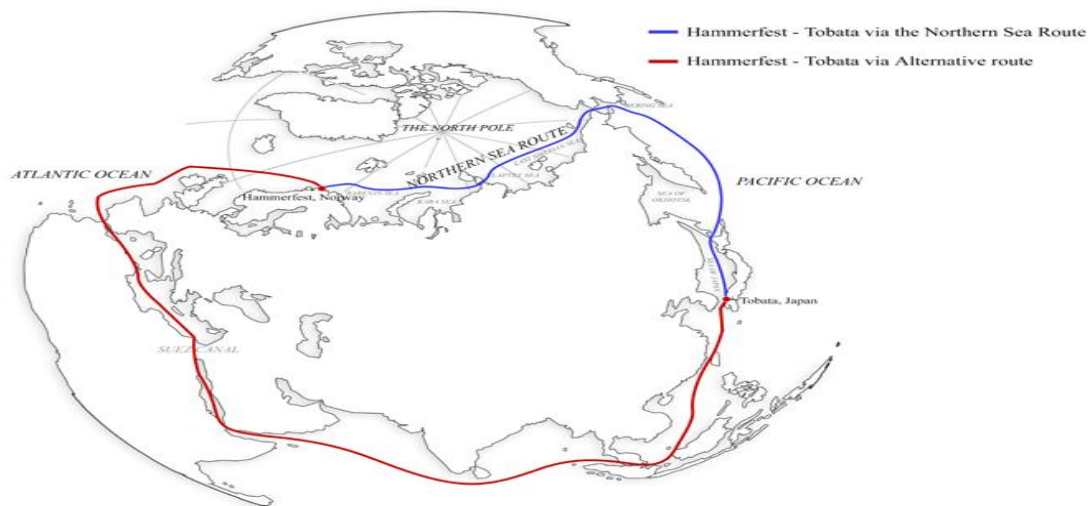


Figure 2.8: Hammerfest to Tobata via NSR and via Suez Canal (Dynagas, n.d)

The researcher interviewed Tony Lauritzen, who is the Chief Executive Officer (CEO) and the operator of the Ob River LNG carrier, to explore about the transportation cost and environmental aspects, because there was no firsthand information available in the existing literature discussing these aspects. Some of the transcripts of this interview addressing the different aspects of this LNG transit voyage via the NSR are presented here to provide the readers with the glimpse of NSR navigation.

The voyage of Ob River through NSR and the problems faced during the planning phase:

*“Actually so far we have done only few voyages through the NSR, the first vessel was Ob River, and we did two voyages with the vessel called Arctic Aurora. Before the actual commencement of voyage, we made a comprehensive plan to perform the voyage successfully. We spent a great deal of time and effort in research and risk analysis. I think we spent nearly one and a half year in doing research and speaking to service providers, to ensure that the voyage was conducted in a diligent way. We also spoke to ice scientists in order to know that what time of the year is good for sailing along the route and when does the ice come, what is the impact of wind and current and so on. Therefore, I think that was the main challenge to complete all the research and risk analysis in an efficient manner until we feel comfortable with that. When we did the actual voyage, it was entirely a new territory for us but we did it in an efficient way with the assistance of the ice pilots who were quite familiar with the area. I would say that the voyage went very well and went much in accordance with what we had expected as we spent a huge amount of time and effort in doing research about the feasibility of the Northern Sea Route” (Lauritzen, 2013).*

Transit shipping along the NSR is largely dependent on the weather and ice conditions. Liu and Kronbak (2010) describe that the ice thickness varies between different geographical parts of the NSR and in different months of the year. Using the icebreaker service is also necessary for crossing the passage in a safe way. For the trans-arctic cargo shipment, the vessel owners need to apply for the official permission of NSR Administration (ANSR) at least four months before the actual commencement of the voyage. In comparison, the permission procedure for Suez Canal is more convenient and the vessel operators can apply for the permission four days prior to the voyage (Liu & Kronbak, 2010). The Russian legislation require that the master or someone who is substituting him must have at least 15 days of ice navigation experience, otherwise there must be a expert ice navigator on the bridge. If a vessel lacks the experienced ice navigator on board, the NSR administration (ANSR) may assign a State Pilot to the vessel, to ensure the safe navigation through the Northern Sea Route (Østreng et al., 2013)

Apart from the ice classification of the vessel, what are the other requirements for LNG vessels transiting the NSR?

*“Yes, of course there are some special requirements, for instance, the compass need to work in a certain way, that means the vessel need to have a modified compass because of its proximity to the north pole. Similarly, when a vessel sails along the NSR it must have some additional*

*communication equipment as the cell phones do not work up along the route. Therefore, you need to install additional equipment for communication and navigation'' (Lauritzen, 2013).*

Østreng et al (2013) state that vessels, which intend to sail in the ice-infested waters should have a special ice class notation. The ice classification of a vessel contains special requirements for the strengthened hull, rudder and propulsion system (Østreng et al, 2013). In addition, more watertight bulkheads, and extra heating arrangements for the fuel and ballast tanks are essentially required for sailing in the icy waters. Different classification societies have mostly similar rules regarding the ice classification of vessels. For example a vessel built under the Lloyd's ice class IL Super can sail under the 'extremely difficult ice-conditions', ships like Ob River that is built to the ice class 1A standard can navigate in 'difficult ice conditions'. Ships with the Lloyd's ice class 1B and 1C are designed to deal with the medium and easy ice-conditions respectively (Liu & Kronbak, 2010).

The Northern Sea Route is geographically a complicated area to navigate and thus demands some additional navigational assistance along the passage such as radio beacons, radar beacons and a reliable positioning system (Østreng et al., 2013)

How were the 'Search and rescue conditions' along the passage?

*''Northern sea route mainly passes through the northern Russia and there are several military bases along the way. There are search and rescue bases under construction along the route. We ensured that we had icebreakers along the way, which is a kind of moving search and rescue base'' (Lauritzen, 2013).*

The marine rescue coordination centers located in Murmansk and Vladivostok, and marine rescue sub-centers along the route, are currently responsible for providing the search and rescue help in case of any incident. These rescue centers offer the different services such as they can send the multipurpose rescue ships to tackle any catastrophic situation, marine special units to deal with the oil spill conditions and finally they use the auxiliary vessels and salvage boats to recover a tragic situation (Østreng et al, 2013).

How were the ice conditions during the voyage?

*‘Through the NSR we have conducted four voyages in four different times of the year, one in July, another in November, and two in October. In July and November, there were the out layers of the ice. Actually, we experienced during the trip, which we started in July and finished in August that, the ice is the out layers of the season. The ice thickness in early months of the season is more difficult to deal with than the later months of the season, because during the earlier months of the season you have the ice that is in the melting process, so it is much harder. In the middle of the season, there is no problem at all, and at the end of the season, there is fresh ice, which is easier to break through’’ (Lauritzen, 2013).*

Harsh ice conditions hamper the smooth navigation through the NSR, the ice massifs along the route may result in damage to the hull of a vessel, reduced speed and extra fuel consumption. As mentioned earlier that the ice-conditions along the NSR vary geographically and seasonally. For instance, both ends of the NSR namely the southwestern Kara Sea and southwestern Chukchi Sea have relatively slight ice-conditions, whereas the East Siberian Sea is famous for having the most difficult conditions for navigation. The NSR navigation in winter season that continues between November and May is extremely hard due to severe ice and therefore ships only can sail in summer season that starts from June and ends in October. However, due to advanced technology and special structure of the vessels it is possible now that the ships can sail even until December (Ragner, 2000)

What was the average speed of Ob River?

*‘Well, it was 12 knots average speed back and forth, as it was the first voyage, so we were little bit cautious about the speed, because we had never been through the NSR before. However, during the second voyage, we sailed in a more comfortable way, and keeping in mind, we followed the icebreakers and they wanted to move little bit faster when we were passing through the parts of NSR. I think in good months you can sail at even 15 knots and in the out layers you probably go port to port around 12 knots average. Indeed, when you go through the ice, which is not such a big distance you will go much slower, you can go down to 4 or 5 knots depending on the nature of the ice. However, from port to port like Hammerfest to Japan you can have full speed in the beginning or at the end of the voyage’’ (Lauritzen, 2013).*

How do you compare the number of sailing days for such a voyage between Hammerfest Norway and Tobata Japan using both alternate passages i.e. the Suez Canal and the NSR?

*“It really depends on how far ahead in time the cargo is sold, how much allowable time you have, nevertheless according to our calculations it was roughly 50 % distance saving and nearly 40% time saving for the transit voyage between Hammerfest, Norway and Tobata, Japan”*  
(Lauritzen, 2013).

Ragner (2000) states that the distance saving between the ports located in northern Europe and northeast Asia can be up to 50 %. The distance between Hammerfest, Norway and Tobata Japan is 6 132 nautical miles via the NSR and 12 146 nm through the Suez Canal, that means the NSR is 50% shorter than the southern route, which ultimately leads to the reduced 20 days of sailing (Falck, 2013)

Can you please provide the amount of fuel consumption during the voyage?

*“I am not able to reveal that but I can just say that we had minimum 40% fuel saving”*  
(Lauritzen, 2013).

What was the charter rate per day and NSR surcharge for the Ob River transit?

*“That it is a commercial secret and therefore I cannot disclose that”* (Lauritzen, 2013).

The researcher did not get any specific information about the charter rate, NSR fee, and the fuel consumption etc. from Lauritzen (2013) the operator of the vessel Ob River. Hagen (2013) who is an active player in the Arctic Bulk commented on this, that the LNG industry is subject to high competition and the disclosure of this kind of sensitive information can negatively influence the business (Hagen, 2013)

How can a rise or fall in the bunker price and NSR surcharge affect the economic potential and the use of NSR?

*“The more high bunker price is, the more attractive Northern Sea Route is and of course, a rise in the NSR surcharge will make it less attractive on the other hand. The NSR surcharge used to be almost equivalent to the Suez Canal fees but now it is higher than the Suez Canal fees”*  
(Lauritzen, 2013).



The NSR surcharge and the bunker price are the critical cost components that can influence the profitability of the vessel operations along the NSR (Liu and Kronbak, 2010).

How much CO2 savings were made by the transit voyage of Ob River.

*“That is about 40% also but keep in mind that these vessels are running on gas and so the CO2 emissions are very low, and of course if you go on ballast and do not have cargo on board then you burn heavy fuel oil and emissions would be comparatively higher” (Lauritzen, 2013).*

The reduced vessel speed along the NSR leads to lower fuel consumption and that eventually results in lower CO2 emissions (Schøyen & Bråthen, 2010)

Other benefits or costs connected to ship operations on NSR over Suez:

*“While making decisions for running vessel operations along the NSR, you need to have a specialized crew who possess the ice navigation experience, you need to spend more in terms of maintenance cost wear and tear of the vessel etc. and that would increase the cost” (Lauritzen, 2013).*

The Russian legislation require that the master or someone who is substituting him must have at least 15 days of ice navigation experience, otherwise there must be an expert ice navigator on the bridge. If a vessel lacks the experienced ice navigator on board, the NSR administration (ANSR) may assign a State Pilot to the vessel, to ensure the safe navigation through the Northern Sea Route (Østreng et al., 2013)

Other risks and challenges for future LNG transits through the NSR:

*“The challenge is, if the Northern Sea Route becomes a popular route in the future it must be ensured, that an adequate number of icebreakers are available to assist the traffic along the route, but I think that is being addressed there. The route has get attention of the higher Russian authorities. Chinese are also more active in the arctic to buy the cargo via that route that is a good sign. The Norwegian authorities are also involved and aware of the challenges and know how to address them because there are also exports from Norway, this is important for Norwegian economy and I expect more developments in the future in this respect” (Lauritzen, 2013).*

19 000 ships sailed through the Suez Canal and 46 traversed the Northern Sea Route in 2012, how would you comment about the potential scope of NSR over the Suez Canal?

*“I do not expect the NSR to be comparable to the Suez Canal at all, the reason for that is whatever commodity you are transporting through the NSR, it needs to be located in the place that makes the distance shorter than an alternative route. Therefore, I do not think that there is sufficient commodity place, for example in northern Norway or Russia to make it competitive with rest of the world. However, I think that for some commodities we can expect a lot more activity in future than what it is today. In particular, if we look at gas, and there is gas in northern Norway to some extent but there are enormous resources in northern Russia and some of them are under construction. Hence, from LNG point of view, we can expect a large increase in LNG traffic along the NSR in the coming years” (Lauritzen, 2013).*

LNG market is undergoing major shifts in trading patterns and Asia is appearing as a largest LNG consumer on the map; do you think that such a shift can have any impact on the prospective use of NSR?

*“Definitely, the main attraction for the Northern Sea Route in terms of gas is because of its easier access for producers in Norway and Russia. The NSR is a shortcut route between Europe and Far East Asia for cargo transportation, so I do expect that in next around five years or so; much more LNG would find its way to the Far East via the Northern Sea Route. The interesting thing in this respect is that for Norway, it was never really feasible to transport large consignments of LNG to Japan or to the Far East in general, the reason for that the Norwegian LNG is comparatively too far away and the other LNG sources are much closer to the far east countries than Norwegian. Therefore, I think that the NSR would play a considerable role to accelerate the exports of Norwegian LNG. We have already shipped a few cargoes to the Far East using the NSR, and these days we are going to deliver one more LNG cargo from Norway to Asia via the NSR” (Lauritzen, 2013).*

Japan suffered major nuclear disaster in 2009 which consequently led to the shutdown of its several nuclear power generation plants, what is your observation that can the NSR be used in this context, to compensate the increased energy needs of Japan?

*‘Well, actually at the moment there is no any nuclear reactor running in Japan, so they need to fulfill their energy requirements by using alternative fuels. This is evident that since years LNG has been a major energy source for Japan, so it is convenient for them to switch to LNG to compensate the short fall created by nuclear disaster. Moreover, LNG is a cleanest, safest and easily accessible fuel in relation to its other close alternates. Japan has already the required infrastructure for LNG, so we can predict that there would be a significant rise in Japan’s LNG imports at least in the short run, and it will be keen to buy gas from whoever can supply gas at competitive price. When you look strictly distance wise, Norway to Japan via NSR is approximately the same distance as Qatar to Japan, so it means that the competitiveness of the Norwegian gas has increased at a very large extent after the emergence of the Northern Sea Route and I think that is going forward. I think that a big part of the Japan’s gas needs would be covered by Northern Sea Route but it would take time to get there. If you look at the total production, Norway is producing 4.5 million tons of gas per annum, whereas, in Qatar the total production is nearly 77 million tons per year. Therefore, this is uncertain in present to predict that how much LNG can flow through the NSR and go to Japan. We simply need more gas, that is the problem, and that is where Russia is coming in where they have some of their major projects will start up in 2018, and I think that would be a big game changer. And I also expect that Norway would work on the expansion of its Barents project in future, because after all the whole concept of producing LNG versus using pipeline is that you cannot reach the markets in the far east or at distant places. Although you can access Europe via pipeline but cannot go for example to South America, Japan or Far East Asia’’ (Lauritzen, 2013)*

The transit voyage of LNG carrier Ob River has opened a new door for the LNG trade between Europe and Asia through a 50% shorter route of NSR. In particular, the competitiveness of the world’s northern gas terminals has increased due to the NSR, as now they have easy access to the energy hungry Asia with reduced sailing days. However, currently there are many uncertainties as the commercial LNG shipping through this route immensely depends on various factors, such as the future ice conditions, Russian legislation, and the LNG prices in the Asian market. The vessel owners need special ice classed vessels with additional navigational equipment and ice qualified crew on board for sailing through the NSR. Savings are quite attractive in terms of lower fuel consumption, reduced sailing days and CO2 emissions. So far, Dynagas Ltd.

### 3. Research Methodology

When the research problem and question for this study is defined and a theoretical framework is developed in the previous chapters, now the question is how the research will be done, what kind of methodology or approach will be pursued to get the answers to the research question? Apart from this, the chapter describes the data collection approach for this study and the last section of the chapter discusses the quality aspect of this study.

The figure 3.1 demonstrates the choices made in respect of methodology. The first step is to identify a relevant research strategy that is a case study for this research 3.2. Next, it comes to decide between available study designs; this research relies on a single case 3.3. Finally, an appropriate analysis approach for this research is determined 3.4.

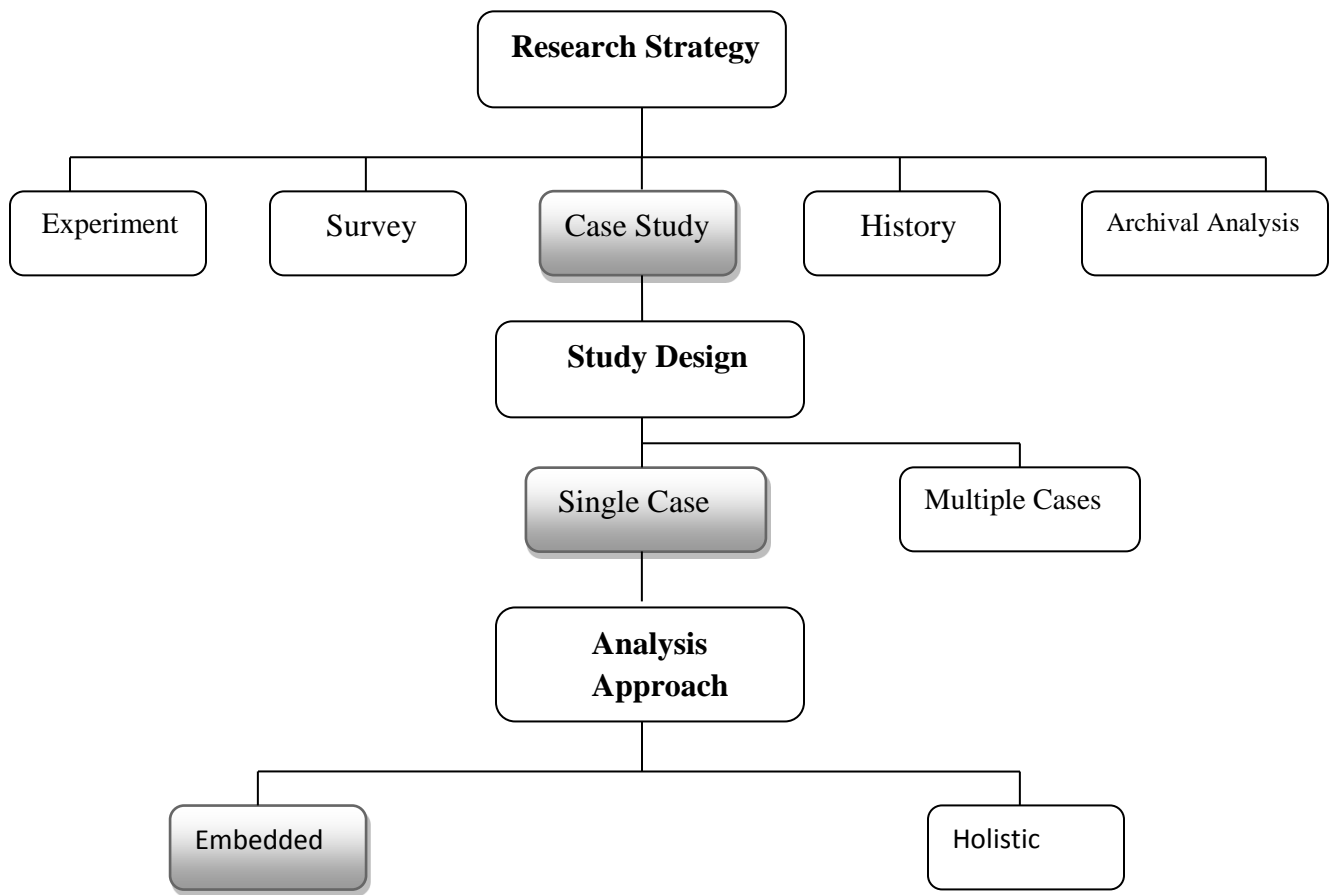


Figure 3.1: Overview of Selections made concerning the Methodology based on (Yin, 2009)

### **3.1 The Study Perspective**

Before explaining the research methodology in detail, it is necessary to have a brief glimpse of the context of the study. Denscombe (2010) states, that the case study method can be used to describe the real life events, process and relationships. It explains a phenomenon and discovers the key issues including the prospects and problems that could have impact on that phenomenon. In order to discover the information and knowledge case study methodology also makes comparisons of the situations (Denscombe, 2010).

This research study describes the existing phenomenon of the Northern Sea route, and explains the relationship between the ice melt, soaring energy demand and the use of NSR particularly for LNG transportation from Northern Europe to Far East Asia. How the receding polar ice has opened new opportunities for the exploration of hydrocarbons and the transarctic shipment of these discovered resources via the NSR is also a part of this report.

The core focus of the study is to assess the economic potential of the Northern sea route and evaluate the CO<sub>2</sub> emissions for an LNG carrier sailing between Hammerfest, Norway and Tobata Japan. The study measures the economic potential at micro level, and compares the cost incurred on a single leg trip between the mentioned ports using the both alternates the NSR and the Suez Canal. The total CO<sub>2</sub> emitted during the voyage will also be calculated and compared to determine the environmental stability.

Although this report discusses the NSR primarily in economic and environmental perspective but in order to have a better understanding of the phenomenon as a whole it seems necessary to indicate the other significant factors involved in NSR, which will be discussed later.

### **3.2 The Research Strategy**

A research strategy is a plan of action formed to achieve a specific and realistic goal and is expected to successfully accomplish the desired task. Selection of a right research strategy relies on the research objective, and a good research strategy is one which best serves the purpose of the project.

The five major research strategies according to Yin (2009) are the experiment, survey, archival analysis, history and case study. Yin indicates that use of these research strategies depends on three main conditions: the type of research question, the level of control over the behavioral events and the contemporariness of the events.

Taking the control of behavioral events and the contemporariness of the events into consideration, there are two options available: the survey method and case study method. However, in this research, the case study approach has been preferred over the survey method as Yin (2009) argues that the case study approach focuses on the holistic and meaningful features of a real life event. Yin describes that the case study approach is appropriate where the researcher has no control of the behavioral events and these events cannot be manipulated (Yin, 2009), and that is rightly true in the case of NSR which is being studied here. In addition, this study asks the how and why questions, which make the case study a more better research strategy.

The case study method is an empirical inquiry and investigates the contemporary phenomenon in more detail and within real life situation whereas the survey approach lacks the in depth study of the phenomenon and cannot investigate the context effectively. The case study approach depends on multiple sources of data and focuses on the distinctive events, which contain several variables. In order to collect and analyze the data, this methodology also takes help from the already existing theory (Yin, 2009). Following the case study approach, this study of NSR specifically investigates the economic and environmental aspects as described earlier. Multiple sources of evidence such as interviews and relevant literature are used to find out the research outcomes for this study.

Case studies have different applications, distinguishing between the theory led and discovery led application of the case studies. Case studies are used to discover the information Denscombe

(2010) argues, but it does not necessarily mean that a case study is bound to serve just one purpose related to one category.

The choices made regarding the case study applications for this study have demonstrated in the figure 3.2.

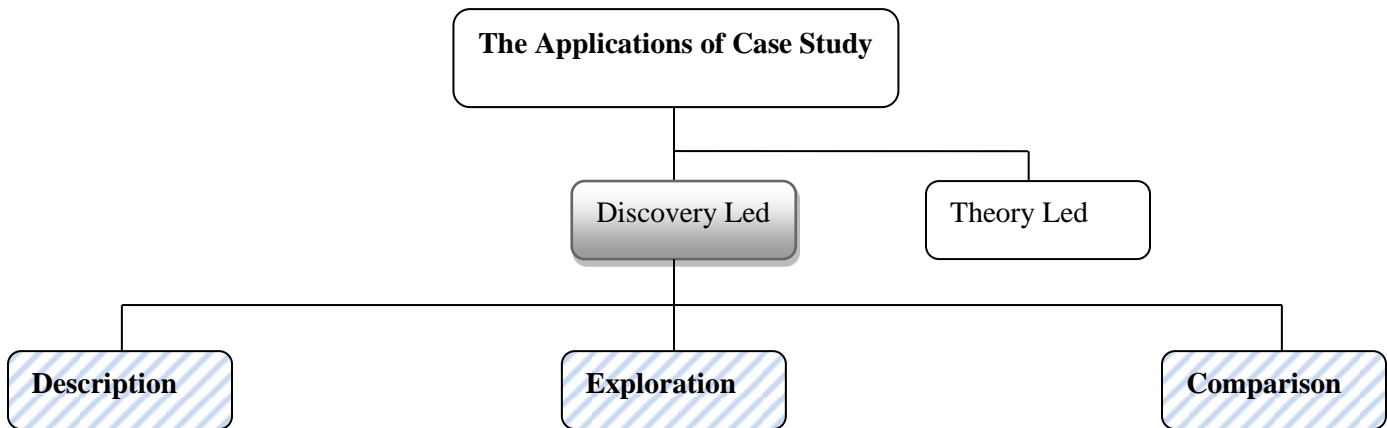


Figure 3.2: Applications of Case Study approach in the NSR study based on (Denscombe, 2010)

The case study approach in this research serves the discovery led purpose as it purveys information to the concerning actors in the maritime sector about the economic and environmental aspects of the LNG tanker sailing between the Norway and Japan via NSR and Suez. The discovery led uses of case study is further divided into descriptive, explorative and comparative uses; these three have been deliberately presented by the blue patterned boxes in the figure 3.2, which implies here that this research report represents all three of them. First, this research study describes the existing phenomenon of the Northern Sea route, and explains the relationship between the ice melt, soaring energy demand and the use of NSR particularly for LNG transportation from Northern Europe to Far East Asia. Secondly, it explores the opportunities for LNG transportation via NSR. Finally, using the case study approach, this research study compares the cost and CO2 factors associated with the NSR and Suez Canal.

### **3.2.1 Objections against the case study approach**

Many researchers oppose the case study approach. Yin (2009) indicates some main concerns about the case study approach. In case study method, researchers often do not adhere to the systematic procedures and their prejudice may affect the outcomes of the research. The second problem is that the findings of case studies purvey the little basis for generalization. Finally, the case studies require more time to produce outcomes. This report intends to fairly follow the defined research objectives in a specific context and avoid any kind of manipulation of research outcomes. Moreover, the findings are generalizable to the theoretical assumptions not to the populations or universes (Yin, 2009). Furthermore, the research question of this study does not require long duration to find the answer, Yin (2009) argues, that the case studies do not always need longer periods to produce outcomes rather the time duration may be shorter depending on the research topic.

### **3.3 Study Design**

In order to address the research question properly it seems necessary here to determine the case study design before the data collection process. Yin (2009) defines two main case study designs that are the single case and multiple-case designs. Both these designs have pros and cons and their use depends on the research problem.

Choosing a multiple case study design requires a great deal of resources and time, which is inaccessible for the investigator. This study opts for the single case to discuss and find outcomes because it is appropriate to use the single case where the case presents a real life event or the case is typical in nature Yin (2009) argues. In addition, the findings of the single case study are supposed to be informative (Yin, 2009). This studies the existing phenomenon of the Northern Sea Route and typically focuses on the commercial and environmental scenario of the route. The outcomes of the case study conducted in this report aim to provide the information to the concerning actors.



### **3.4 Analysis Approach**

When the design of case study is determined, the next step now is to identify whether the single case will be embedded or holistic. The embedded analysis emphasizes on one or more subunits of an event under consideration, whereas the holistic analysis focuses only on the universal nature of a project. The main problem with embedded analysis is that it may ignore the holistic nature of the case by emphasizing too much on the sub units and that will eventually change the nature of the case. The holistic approach on the other hand has its own pitfalls such as the case study using the holistic design may investigate an event at an abstract level and lack the sufficient criteria or data for investigation (Yin, 2009).

The Northern Sea Route is an extensive topic and has various perspectives such as geographical, economical, geopolitical, technical and environmental etcetera. Conducting a holistic study to investigate all the different areas of the NSR in detail is not feasible due to limited resources. The research question of this study examines mainly the economic and environmental units and the report aims to compare the sailing costs and CO<sub>2</sub> emissions for an LNG carrier navigating along the NSR and Suez Canal. The subunits provide the considerable opportunities for the extensive analysis and assist to develop a clear insight about the single case Yin (2009) argues.

### **3.5 A Qualitative Study**

Denscombe (2010) states, that for data analysis and interpretation, quantitative or qualitative approach is used depending on the nature of the data. In real world, the distinction between both approaches is sometimes hard to determine. Denscombe (2010) lays stress that the distinction between quantitative and qualitative should relate to the treatment of data, instead of types of research as itself (Denscombe, 2010).

The quantitative research tends to use numbers as an analysis unit and is objective in nature. This approach supports the large-scale studies that involve larger quantities. The large size of investigation in quantitative research makes the findings of such research more generic. The quantitative research emphasizes on the analysis of specific variables in isolation or in a connection to a limited range of other variables, thus it restricts the opportunity for a holistic study (Denscombe, 2010).

In contrast, the qualitative research relies on spoken or written words and observed images as the unit of analysis, and interprets a research phenomenon. This type of approach favors the small-scale studies and the researcher using this approach usually has a profound understanding of the data for analysis. Contrary to the quantitative research, the qualitative research describes a phenomenon in its overall context and explores the relationship of various variables involved in that phenomenon. Therefore, this approach has a tendency to present a holistic perspective of the phenomenon of a research investigation. This type of approach is mainly associated with research strategies such as case study, phenomenology and grounded theory etc., and uses the research methods like interviews, documents and observation Denscombe (2010).

This research is inductive in nature as it particularly explores the environmental and economic perspective of the NSR and then interprets the research findings in general context of NSR. Therefore, it seems necessary to pay attention to the relationships between several significant factors involved in the NSR. The quantitative approach fails to present the holistic view of the study here as it just emphasizes on specific variables, which do not make a clear understanding of the phenomenon as a whole. Contrary to the quantitative research, this study discusses the NSR at a small-scale level and it does not involve any larger number or quantities. Some may argue that, the economic potential and CO<sub>2</sub> emissions are measured in digits so it should be a quantitative study, but the fact is that these numbers or quantities were interpreted in words as a unit of analysis, and no any statistical analysis was performed on the data. The mentioned reasons justify the qualitative method as a more relevant choice for this study.

### **3.6 Data Collection**

Data collection is an important part of a research work, and there are no hard and fast rules for using any specific method because it mainly depends on the nature and objectives of a research study. This research however, commenced with the secondary data. The researcher read the literature about the NSR that includes research articles, reports, journals, books, maritime newspapers etc.

The intention of the researcher was to obtain the real time and updated data regarding economic and environmental segments of the Northern Sea Route to meet the goals of this study. However, the available literature did not purvey the essentially required information in this respect.

Therefore, in order to ensure the quality of this report and to acquire more relevant and specific data, certain interviews were conducted with the concerning actors in the maritime industry.

### **3.6.1 Interviews**

Yin (2009) describes the interviews as one of the most significant sources of information for the case study research work. Interviews are usually guided conversations instead of rigid enquiries, and they provide an insight to a researcher about the matter of a study Yin (2009). Denscombe (2010) argues that even the interviews and conversations are similar up to a certain extent but interviews have broader spectrum than the conversations because interviews follow a set of assumptions and the involved parties normally have an understanding of the matter of discussion (Denscombe, 2010). Easterby-Smith et al (2008) quotes the significance of interviews as, that interview provide an opportunity to a researcher for a profound investigation to unveil new ideas, to touch the new dimensions of a problem and to obtain relevant and specific information based on the personal experience of the interviewees (Easterby-Smith et al, 2008).

#### **3.6.1.1 Selection of Interviewees**

Denscombe (2010) describes that the interviewees are selected because of their contribution, their unique insight and or considering their position they hold. But there is no hard and fast rule in this respect and it largely depends on the overall aim of the research (Denscombe,2010).

The selection criteria for the participants of this study were based on the following key elements;

1. The nature of the research question and the goal of the study
2. Knowledge of the researcher
3. Relevant experience and position of the participants
4. Availability of the participants

Bearing the above-mentioned factors in mind the concerning participants were contacted by email and phone to have an appointment for the interview. The response from the participants on this was varying. Most of the participants were willing to participate but some did not even respond the queries asking for interviews.

A list of all the persons along with their relevant status, who contributed with the appropriate information and helped to get hold the right persons in this respect, is presented in the following table: Østreng, (2013).

<b>Interviewee's Name</b>	<b>Affiliation</b>	<b>Position</b>
<b>Willy Østreng</b>	<b>The Norwegian Scientific Academy for Polar Research</b> Svalbard, Norway	President
<b>Tony Lauritzen</b>	<b>Dyna Gas Ltd.</b> Athens, Greece.	CEO
<b>Henrik Falck</b>	<b>Tshcudi Shipping Company As</b> Lysaker, Norway	Project Manager-Eastern Europe
<b>Ulf Terje Hagen</b>	<b>Arctic Bulk AG &amp; Tschudi Arctic Transit As</b> Lysaker, Norway	Director, Managing Director
<b>Alf Roar Olsen</b>	<b>Knutsen OAS Shipping</b> Haugesund, Norway	Maintenance Manager, Dual fuel Gas Engines
<b>Oivin Iversen</b>	<b>Hoegh Flng Ltd.</b> Oslo, Norway	CEO
<b>Vegard Hellekleiv</b>	<b>Hoegh LNG AS</b> Oslo, Norway	Senior Vice President of Project Services
<b>Kristian Foring Devik</b>	<b>Hoegh LNG AS</b> Oslo, Norway	Project Engineer New building and Technology

<b>Egil Rokstad</b>	<b>RS Platou ASA</b> Oslo, Norway	New Building/ LNG group
<b>Tommy Dahl</b>	<b>Hoegh LNG AS</b> Oslo, Norway	Project Engineer – New building & Technical Development
<b>Reidun Eikeland Haahjem</b>	<b>Gard AS</b> Bergen, Norway	Vice President/ Area Manager
<b>Inna van Spriel</b>	<b>Skuld As</b> Oslo, Norway	Senior Claims Executive

Table 3.1: List of Interviewees with their respective affiliations and positions

In addition to above-mentioned interviewees, an anonymous interviewee came up with the insurance costs for the calculations in chapter 5. Due to confidentiality reasons the details about the anonymous interviewee are not shared in this report.

### 3.6.1.2 Interview Issues

Interviews are used to get the data to meet the research goals appropriately. Apart from the skills needed for conducting interviews in an effective way it is also necessary to look at that how a researcher organizes and structures the interview.

Easterby-Smith et al (2008) states that there are some practical issues involved in conducting the interviews and if they are not addressed carefully, they may affect the expected outcomes of the interviews. What are these issues and how the researcher tackled them in his particular setting, is described in the following steps;

#### **Obtaining Trust and Social Interaction**

In order to get the accurate and reliable information from the interviewees it is essentially significant that the interviewee has the trust and confidence on the researcher, otherwise interviewees may feel uncomfortable and may not expose the true and relevant information, which eventually can influence the quality of the interview. These are the first two issues pointed out by Easterby-Smith et al (2008).

In the beginning, couple of interviewees seemed little bit concerned about the authenticity of the researcher and his work, at that time researcher had just presented his research topic to the concerning interviewees through a concise email. Afterwards, a proper information sheet (see Annex) was prepared which includes the brief components such as, the nature and scope of the project, the responsibility of the researcher and interviewees and the addresses of the researcher and his supervisor etc. to build a sort of confidence. In addition, a consent form (see Annex) was also prepared to take a proper consent of the interviewees, where they were ensured that their participation is voluntary and the researcher and his work do not intend to harm them in any way.

The researcher read the information sheet and consent form before starting the interview, and got signatures of the participants on the consent form. Thus, these tools assisted to build confidence between the participants and the researcher up to a certain extent.

The attainment of relevant cost and CO<sub>2</sub> figures connected to LNG shipping through the Northern sea route, which form the fundamentals of this report, was a big challenge for the researcher. There are only few LNG shipping companies in the world that can operate in the Northern Sea Route, Dynagas Ltd. and Knutsen OAS Shipping, are two of them. It is important to mention here that, Dynagas has conducted four voyages already through the Northern Sea Route. The representatives from both the mentioned companies declined to provide the required primary data for being highly sensitive information. When consulted on this situation with Ulf Hagen a respondent from Arctic Bulk shipping company, the researcher learnt that due to highly competitive nature of the LNG industry it is hard for private companies to reveal such figures. However, these companies provided the other relevant information that was still important for this report.

### **Using the Appropriate Language**

The use of language is considerably an important element that should not be ignored while preparing the interview guides etc. For this research study, all the interviews were conducted in English language that of course is second language for both the researcher and the interviewees. The researcher prepared the interview guides in a professional but simple manner. The interview guides were comprised of the open-ended questions related to the research topic. After getting the feedback on the interview guides from supervisor they were sent to the concerning

interviewees in advance, so they could read them and ask about ambiguities if any. The purpose behind this was to assist the interviewees to construct their relevant pool of knowledge and ideas in a better way for the interview.

### **Getting Access**

For the researcher, conducting the interviews has been a challenging task, it was hard to get hold the right persons and to get the required data. For instance, Gazprom and Statoil are the two major gas companies who have operations in the high north and have sent cargo through the NSR in 2012. The researcher tried to approach these companies by phone and email for data collection, but they did not respond at all. Similarly, one of the key participants in a shipping company, due to his busy schedule postponed the interview for even three times.

However, some interviewees for instance Willy Ostreng and Henrik Falck proved kind in this respect. Henrik Falck even assisted the researcher to be holding the other more relevant contacts in Hoegh LNG Company, as Tschudi Shipping mainly deals in Bulk cargo and therefore Henrik was unable to provide the basic figures related to LNG vessels. Henrik also offered the researcher with a research publication titles '*Shipping in Arctic Waters*', as Yin (2009) argues that interviewee also can suggest other persons for the researcher to interview and other sources of evidence.

### **The Location of Interview**

Selecting a suitable place for the interview is an indispensable factor that may influence the interview quality. Denscombe (2010) describes that in face-to-face interviews the place and time of interview should be pre decided with mutual consent of the parties. Denscombe emphasizes that the selected place for interview should be quite and calm and the both the persons should sit at 90-degree angle to each other to allow the eye contact.

The interview with Willy Ostreng held in a pleasant environment of a coffee shop in downtown Oslo that continued for nearly two hours. The time and place for this interview were decided mutually during the phone conversation. The researcher visited Henrik Falck the interviewee from Tschudi Shipping in his office located in Lysaker, Norway.

Due to limited resources, it was not possible for the researcher to travel more, so after talking to the persons in Knutsen Shipping and Hoegh LNG a typical list of questions about the figures such as Fuel Consumption, Cost and CO2 emissions etc. was sent to them, which they returned after filling in their responses. To save the interview cost and time the interview with the CEO of Dyna Gas Ltd, Tony Lauritzen, was conducted by telephone. Ulf Hagen from Arctic Bulk also provided the information on phone. After the interviews, the researcher sent thanks emails to all the interviewees for their contribution.

### **Recording the Interviews**

In order to use the information shared during the interview a researcher can rely on memory. However, the human memory is rather unreliable and subject to bias and error. That is why researcher can use a permanent mode of recording the interview discussion and re-listen for analysis later on (Denscombe, 2010). Yin (2009) says that audio tapes provide a more accurate version of any interview than any other method. The decision to use the recording device mainly depends on the interviewee's consent, if the recording device disturbs the interviewee in any way it should not be used (Easterby-Smith et al (2008)).

The researcher recorded three interviews held with Willy Ostreng, Henrik Falck and Tony Lauritzen. These participants allowed the researcher to record the interview as there was no confidential information shared. The interviewees did not get any disturbance from the recording device and all the interviews went smoothly. In addition to the recording, researcher jotted down some field notes also to secure a kind of back up.

### **Ethical Concerns**

According to Yin (2009), one of the most significant concerns involved in research and data collection is, that how a researcher addresses the confidentiality aspects of research. Since the case study research mostly involve human affairs and it discusses real life events therefore, a researcher should conduct all his research in accordance with the highest ethical standards. Yin (2009) mentions some key factors, which must be considered to protect the participants of the study from any harm. These factors includes, acquiring the informed consent of participants, privacy and confidentiality of data and avoiding harm and deception to the participants etc.



The researcher strictly followed the principles of ethics. All the participants were informed explicitly about the nature, scope and goals of this research study. An appropriate information sheet was prepared to make the interviewees acquaint of this research study. The information sheet delivers some crucial knowledge to the interviewees such as, the introduction of the researcher, a description of the research study, the roles and responsibilities of the researcher and interviewee, the permission to record the interview, the addresses of the researcher and his supervisor, that may be useful in case of any enquiry by the interviewees (see Annex).

Along with the information sheet, a consent form was also developed to cope with the confidentiality and privacy issues. The participants marked the relevant options of the consent form and signed it. An example of the consent form is provided in the annex of this report. The information sheet and consent form along with the interview guide were sent to the interviewees via e-mail before the actual interviews held.

The participants did not reveal any confidential information during the interviews and they had not any special concerns about anonymity of their names. It is important to mention here that, Dynagas has conducted four voyages already through the Northern Sea Route and they have the most updated information about the economic and environmental aspects of the route. However, the CEO of the company declined to provide the required primary data for being highly sensitive information. An in-depth interview with the CEO of Dyna Gas Ltd. is demonstrated in the Empirical Study chapter of this report.

Due to above mentioned reasons, the researcher declared all the interviewees along with their affiliation and concerning roles (See Table 3.1) as none of them had any concern on this. It is also necessary to state here that, to obtain the objectivity the researcher discussed the interviews with the interviewees to confirm that the interviews are interpreted accurately. In addition, later on the researcher sent the interview by e-mail to the participant with the aim to allow removal or addition of statements if needed.

Overall, interviewing was a wonderful experience for the researcher as he exercised the importance of the interviews as a data collection tool. In addition, researcher got an ample amount of information related to the research topic.

### **3.7 The Research Quality**

Yin (2009) states that four kinds of tests are widely used to assess the credibility and quality of an empirical social research and since the case studies are also one form of such research, therefore these four tests are also relevant to case studies. What are these four tests and how the researcher applied these tests to ensure the quality of his work is demonstrated in the following;

#### **3.7.1 Construct Validity**

The first test is to construct validity, which deals with the identifying right operational measures for the concepts under study.

The research question of this study is very broad in nature that explores the economic and environmental potential of the route. The economic and environmental potential can cover a wide range of factors and thus it is hard to construct validity. The researcher measures the economic and environmental potential in terms of cost components and CO<sub>2</sub> emissions respectively and explains these figures in overall context of this study, which is presented in detail in the last chapter of this report. The researcher compares these figures in Northern Sea Route and Suez Canal settings. Researcher used multiple sources of evidence including journal articles, research reports, books, interviews etc. to collect the data, as Yin (2009) argues that use of multiple sources of evidence is effective tactic to construct the validity.

#### **3.7.2 Internal Validity**

The second test is about determining the internal validity of the research findings. Internal validity measures that up to what degree the findings or results of a research follow the plan or research question of the study. A researcher should make it sure that the findings are exactly in accordance with the goal of the research.

The researcher presented the background and introduction of the study and the research problem was defined in chapter one. The plan of the researcher was to measure the economic and environmental potential of the NSR in comparison to the Suez Canal. The intention was to make this study more realistic but the achievement of real time data in this respect was a hindrance. Because of this, certain assumptions were made based on the studies of Schoyen et al (2010) and Liu et al (2010). These assumptions were primarily made for the cost and CO<sub>2</sub> components

connected to a vessel sailing between Norway and Japan via NSR and Suez Canal. Moreover, the researcher also explored the impact of variations in the energy market and the evolution of shale gas on the prospective use of the Northern Sea Route for LNG shipping segment. Nevertheless, the findings of this research demonstrate what the researcher had intended to measure or find, and the research goes in accordance with the plan.

### **3.7.3 External Validity**

External validity test pays attention on the generalizability of the research findings. Yin(2009) states that external validity problem is a major obstacle in doing case studies, and the opponents of the case study research argue that single cases provide a weak basis for generalizing of the findings. Yin (2009) argues that the findings of the case study research however are generalizable to theory.

This case study is representative up to a certain extent for other cases and the findings of this study are generalizable to the cases that assume the similar assumptions and pattern of doing research. The findings of this study can be applied to a certain level to the research theories covering other shipping segments such as container and bulk shipping. For instance, one of the findings of this research is that the LNG vessels sailing between Hammerfest, Norway and Tobata, Japan through the Northern Sea Route emit lesser amount of CO<sub>2</sub> in comparison to the same vessels traversing via the Suez Canal. The researcher argues that the other vessels sailing between the above-mentioned ports would also emit lower carbon dioxide (CO<sub>2</sub>) through the NSR in comparison of the Suez Canal because of the fact that the distance is same for all types of vessels. Therefore, the researcher claims that the findings of this research are generalizable up to a certain degree.

### **3.7.4 Reliability**

The fourth test that is used to assess the quality of a research work is the reliability of the work. The purpose behind this is to make sure that the research should produce the same results if repeated later on. The ultimate goal of this test is to reduce the errors and bias in a study (Yin, 2009).

This research study is reliable and generates the same results if repeated, but a condition for this is that the later researcher should follow the same methodology and assumptions as used in this study. Yin (2009) argues that a prerequisite for reliability test is that, if other researchers want to repeat an earlier case study they need to comply with the procedures followed in the earlier case. If the later investigator alters, some of the basic components in his research such as, charter rate for the vessel in question, loading and discharging ports, fuel type of the vessel and the NSR surcharge etc. then the research findings would not match with the outcomes of this research study. Thus, if a similar research study is conducted using the same methods and data it would most likely produce the identical results.

## 4. Case Study

As discussed earlier that several studies are conducted to evaluate the feasibility of the transarctic shipment of different cargoes, mainly focusing on the container and bulk cargo. However, the researcher could not find any comparative study in the pool of existing literature, which addresses the commercial aspects of LNG cargo transportation through the Northern Sea route. This chapter intends to investigate the economic and environmental feasibility of transit shipping of LNG cargo via the NSR as an alternate to Suez Canal. A case study is conducted to compare the different shipping components

Østreng et al (2013) describe that there are three main approaches widely used to make comparisons and analyzing the economic feasibility. The first method is that, calculate the total transportation cost for using each route to get the dollar per ton (\$/ton) cost of cargo for each route. Another approach is, based on assumed annual quantity of cargo shipment; calculate the total cost of starting up a regular service. The final approach in this respect is that, merely compare the cost differences among the alternate routes (Østreng et al, 2013).

Since this research compares the different cost components of transportation of LNG cargo between Hammerfest, Norway and Tobata Japan on round voyage basis and ultimately gets per ton and MMBtu cost of LNG, for both routes. In addition, the study performs the sensitivity tests based on certain cost components to assess the impact of critical cost elements on the total cost structure. Taking the total fuel consumption for both routes into account, this study calculates the total CO<sub>2</sub> emissions for both routes. Therefore, this study uses the first and third approach for economic and environmental comparisons

### **4.1 LNG Shipping from Hammerfest (Northern Norway) to Tobata (Northern Japan)**

Since the research question of this study explores the comparative potential of NSR between Europe and Asia, therefore this section selects the loading and discharging ports for the case study. The World's first LNG carrier Ob River that traversed the NSR loaded her cargo from

Hammerfest and discharged in Tobata, Japan. Same ports as used by Ob River are chosen for the case study in this section.

Norway is one of the world's largest gas exporters. The Snøhvit gas field in northern Norway is the northernmost LNG facility on the map that is located about 140 kilometers north of Hammerfest. Snøhvit gas facility does not have any surface installation and the gas is delivered through the pipeline to the north-west coast of Melkøya near Hammerfest, where this gas is converted into LNG. Out of nine planned wells, six were bored back in 2004 and 2005. This LNG facility commenced working in 2007 (Østreng et al., 2013).

The annual export of LNG from Melkøya is 5.75 billion cubic meters and nearly seventy LNG cargoes are shipped from this facility each year, with most of the output is transported to US and Spain (Offshore, 2013). Hammerfest is located at the gateway to this emerging Northern Sea Route. As mentioned earlier, that the ice classed LNG carrier Ob River loaded its eastbound LNG cargo from Melkøya gas terminal late in 2012 and navigating through the NSR it discharged 63,668 metric tons of cargo at the Tobata gas terminal in Japan (Offshore, 2013)

Experts have the opinion that this first transit voyage of any LNG carrier through the NSR is of considerable significance, in particular for both Norway and Japan. Since, Japan would need more LNG after the shutdown of its nuclear power plants and Norway would look for new customers due to the shale gas discovery in US, who is the major consumer of Norwegian LNG (Nilsen, 2012). Arctic Aurora was the second vessel who took her maiden cargo from the Hammerfest and set sail towards port of Futsu, Japan through the NSR in 2013 (Staalesen, 2013). The opening of the NSR has increased the competitiveness of Norwegian gas in the Asian market says (Lauritzen, 2013).

According to (Kumar et al., 2011) Japan is the largest consumer of LNG in the world. Tobata gas terminal is located in northern Japan and is operated by Kitakyushu LNG Corporation. The first delivery to this terminal was made in 1977, and Sakhalin gas facility in Russia and Bontang in Indonesia are the main suppliers of LNG to this terminal. Kyushu Electric Power, Nippon Steel, Tobata Cooperative Thermal Power, and Saibu Gas are the main users of this imported LNG in Tobata. Ships with 287.5 meters of length and 47.2 meters width can deliver to this LNG

terminal. Three LNG loading arms at the Tobata LNG terminal can support the flow of 4,100 cubic meters per hour (Zeus, 2006)

A conceptual model adapted from (Schøyen & Bråthen, 2010) is used in this study to determine the economic and environmental feasibility for a round trip of the LNG carrier navigating between Hammerfest and Tobata via the NSR and via the Suez Canal. See figure 4.5,

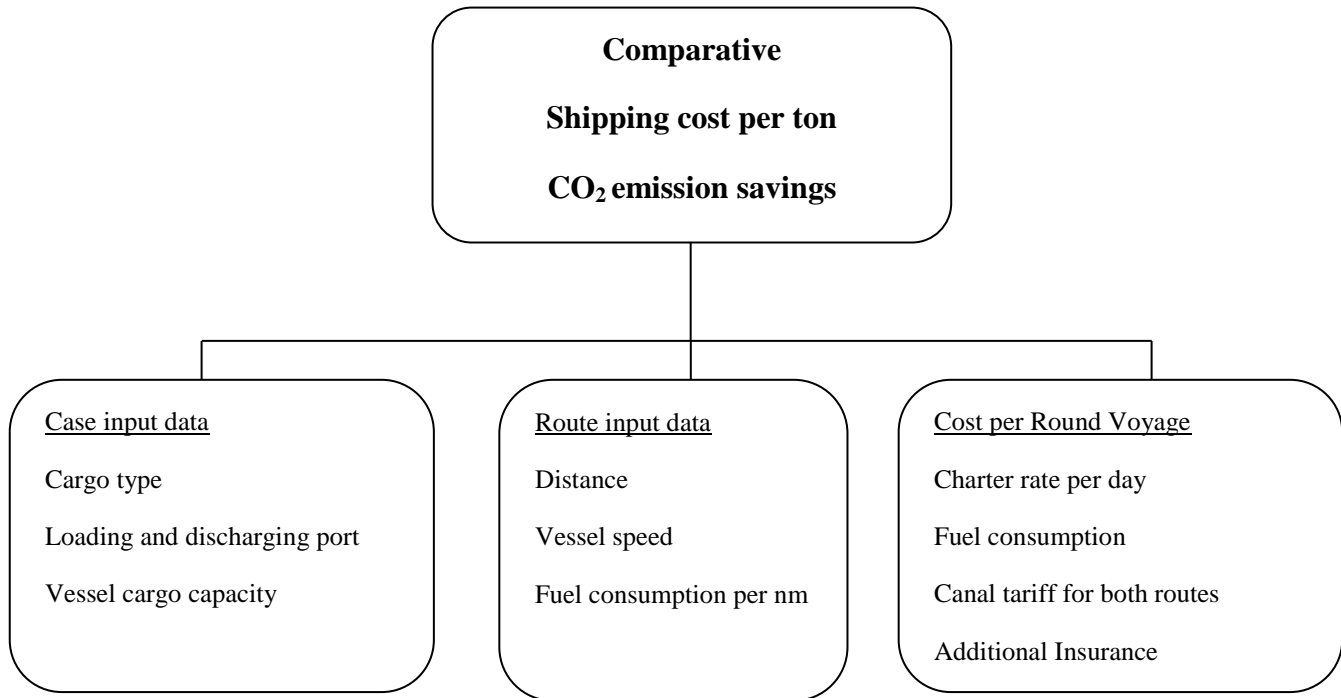


Figure 4.1: Conceptual model for Cost and CO<sub>2</sub> calculation adapted from (Schøyen & Bråthen, 2010)

## 4.2 Case Input Data

This case study aims to explore that how much savings can be generated in terms of cost and CO<sub>2</sub> emissions by sailing through the NSR as an alternate to Suez Canal. An LNG carrier with the similar characteristics as the Ob river is selected for this study, the calculations are made by the researcher based on the data gathered from relevant experts in the respected field and these calculations do not represent the Dyna gas Ltd. or any other participant, who provided information to accomplish this study.

It is assumed, that the vessel sails through the NSR during the navigable months depending on the ice conditions in NSR and is positioned in other regions during the winter season. The calculations in this study are made for a full round voyage between Hammerfest and Tobata Japan. The vessel makes a laden voyage from Hammerfest, Norway towards Tobata gas terminal Japan and after discharging the cargo there, it set sails on ballast back towards the loading point in Hammerfest.

The following table demonstrates the vessel particulars. Some of the components may slightly differ from the actual vessel such as the actual vessel has capacity of 1 49 755 cubic meter, but in this study it is assumed as 1 50 000 cubic meters. The cargo on board is 1 35 000 cubic meters that is equivalent to around 67 500 metric tons.

<b>Case input data</b>	
Vessel type	LNG carrier (Mark 3 membrane)
Ice class	Lloyd's 1A (Arc4)
Gross Tonnage	1 00 244 tons
Dead weight tonnage	84 682 tons
Size	Length : 28 meters & beam : 44 meters
Draft	9.3 meters
Capacity	1 50 000 cubic meters
Cargo on board	1 35 000 cubic meters or about 67 500 tons
Vessel Displacement	1 16 325 tons
Propulsion	DFDE (Dual Fuel Diesel Electric Propulsion)
Port of loading	Hammerfest, Norway
Port of discharge	Tobata, Japan

Table: 4.1 Vessel Specifications based on (ShipSpotting, 2013) and (Lauritzen, 2013)



### 4.3 Route Input Data

Based on the vessel information, the fuel consumption and CO<sub>2</sub> emissions are calculated and compared, for the vessel sailing between the Hammerfest and Tobata via the NSR and Suez Canal, See table 4.2.

**Route Input data (Hammerfest-Tobata)**

Data	Suez Canal	Northern Sea Route	
		Ice Water	Non-Ice Water
Distance between Hammerfest-Tobata (nm) (Falck, 2013)	12 146	2 880	3 252
Speed (knot)	19.5	12	19.5
LNG fuel Consumption (tons per nm)	0,28 (for laden Trip) 0,27 (for ballast Trip)	0,16(for laden Trip) 0,15(for ballast trip)	0,28(for laden Trip) 0,27(for ballast Trip)
LNG fuel Consumption (tons)per round voyage	6 680	893	1 789 = 2 682
LNG wastage in GCU in NSR (tons)		500	
LNG fuel cost per round voyage (\$505/MT FOE)	3 373 400		1 606 910
MDO pilot fuel (tons)	67		32
MDO pilot fuel cost per round voyage (\$ 900/MT)	60 300		28 800
Total fuel cost (\$) per round voyage	3 433 700		1 635 710
Savings on fuel cost (\$)		1 797 990 (52%)	

CO <sub>2</sub> emissions(tons) per round voyage (IMO, 2009)	18 585	8 854
CO <sub>2</sub> emission Savings (tons) per round voyage	9 731 (52%)	

Table: 4.2 LNG shipping. Comparison of Fuel consumption and CO<sub>2</sub> emissions through NSR and Suez Canal

The above table is commented as under:

### **Distance**

The distance between Hammerfest and Tobata through the Suez Canal is 12 146 nautical miles, and through the NSR is 6 132 (Falck, 2013). In table above the distance through the NSR is split into ice water and non-ice water, because in ice water, the vessel would sail at a reduced speed and that will influence the vessel's fuel consumption. The recent experience shows that the LNG carriers traversed the NSR in average 10 days at an average speed of 12 knots (Falck, 2013). Based on this the distance of 2880 is calculated for the sailing in ice water. Any possible delays due to bad weather or administration are not taken into consideration for the calculations in the table.

### **Speed**

The normal speed for LNG carriers is 19.5 knot (Olsen, 2013). According to Lauritzen (2013) the speed of the vessel entirely depends on the ice conditions in NSR, however the vessel speed for first LNG transit voyage via NSR was 12 knot on ballast and laden voyages. At the beginning and end of such voyage between Hammerfest and Tobata, the vessel navigates at its full speed (Lauritzen, 2013)

### **Fuel Consumption**

Using the above information, the researcher assumes that in normal waters, the vessel navigates at its full speed of 19.5 knot and in ice-infested water of NSR it sails at average 12 knots.

All the fuel consumption calculations are done in accordance with the guidance and information obtained from experts. The values for the fuel consumption for this typical vessel assumed in this study are obtained from (Olsen, 2013; Rokstad, 2013; Devik, 2013)

After making the fuel calculations for this vessel, the researcher sent it to (Olsen, 2013) and (Falck, 2013) for quality check and certain changes are made according to their comments on this.

### **Pilot Diesel**

Since the vessel has DFDE propulsion that allows the use of different fuels for sailing, a vessel can use LNG or diesel. An assumption is that the vessel consumes LNG for propulsion on the laden and ballast voyage.

### **LNG Fuel**

The LNG fuel consumption for such a vessel is 130 metric tons per day at 19.5 knots and 45 tons per day at 12 knots on a laden voyage. For the ballast voyage, the vessel consumes 126 metric tons of LNG at 19.5 knots and about 42.5 tons at 12 knots (Olsen, 2013). Based on this the per nautical mile LNG fuel consumption is computed that slightly varies for a laden and ballast voyage.

### **Gas Wastage in Gas Combustion Unit (GCU)**

In the laden voyage, the vessel must consume at least 95 tons of fuel per day at 0.14 percent of boil off gas (BOG) rate. However, in NSR, the vessel consumes only 45 tons of LNG at 12 knots speed, therefore the rest of 50 tons BOG per day is wasted in the Gas Combustion Unit (GCU) (Olsen, 2013; Rokstad, 2013). The total BOG wastage for this trip is 500 tons for ten days on the laden voyage as there would not be such any wastage on the ballast trip.

An important factor in this respect is that, some modern LNG vessels have the ability to re-liquefy the boil off gas (BOG) by using the advanced technology, so it is assumed that the vessel in study does not have any such technology on board (TimeraEnergy, 2013).

### **Price**

Currently according to (Olsen, 2013) LNG price is 12 US dollars per Million British Thermal Unit (MMBtu) in Europe, and one cubic meter is equivalent to 20 MMBtu. Using a fuel oil equivalent (FOE) factor of 0.475 cubic meter LNG/ per fuel metric ton, that is commonly used

in LNG industry, the per ton fuel price of LNG is derived that is 505 US dollars per ton (Olsen, 2013).

The DFDE LNG carriers also consume a small amount of pilot diesel, which is around 1 percent of the total fuel consumption (Olsen, 2013), (Devik, 2013) and (MAN, 2013). The current bunker price of diesel oil is around 900 US dollars per ton in Singapore market (Bunkerworld, 2013)

The following figure demonstrates the total fuel consumption including the LNG and pilot diesel for both routes.

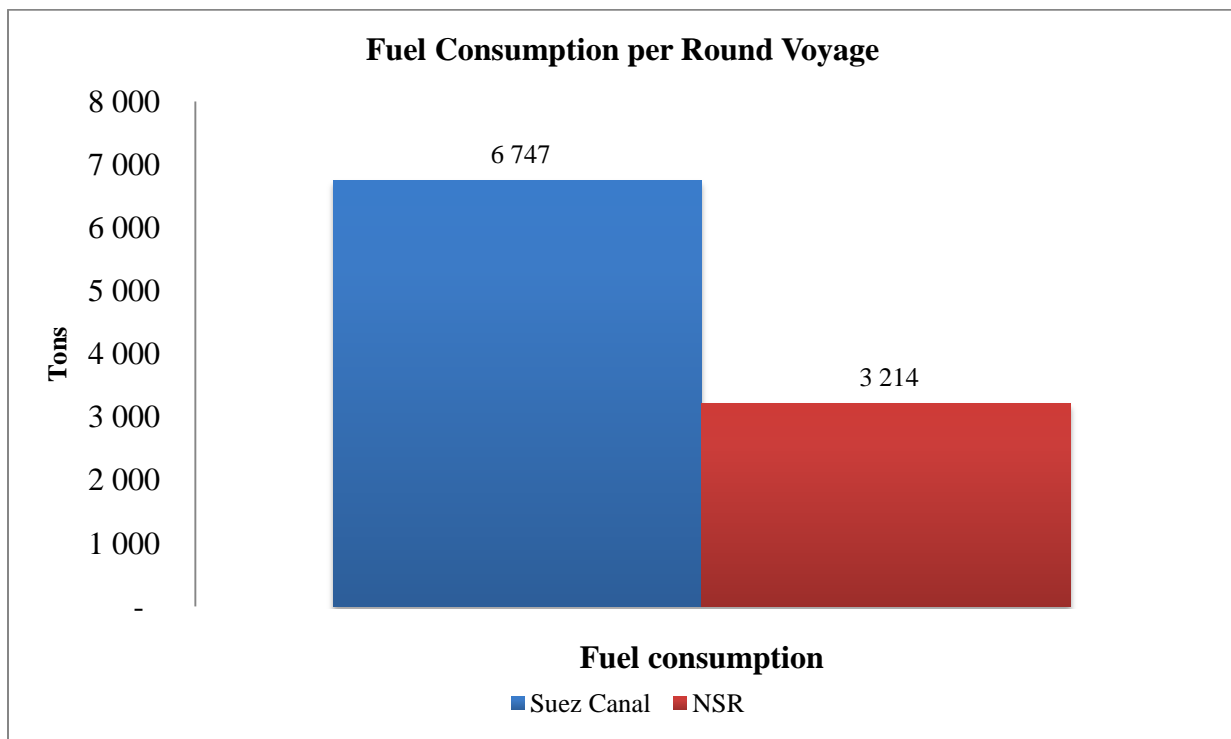


Figure 4.2: Total fuel consumption per round voyage via NSR and via Suez Canal

The figure shows that the NSR is 52 % efficient in terms of fuel consumption due to the shorter distance, and by sailing via the NSR an LNG carrier can save 1 797 990 US dollars in terms of fuel cost at a current bunker price, on a round trip with the stated assumptions. In spite of the fact that there is wastage of around 500 tons of BOG in GCU during the NSR navigation, but still the NSR is more economical at least in terms of fuel consumption.

Based on the fuel consumption the total CO<sub>2</sub> emissions are calculated for this voyage between Hammerfest and Tobata. The total CO<sub>2</sub> emissions include emissions on LNG fuel consumption

and pilot diesel consumption. IMO (2009) guidelines are used here to obtain the net CO<sub>2</sub> figures. The factor 3.206000 is multiplied with the total diesel oil (tons) consumed and factor 2.750000 is multiplied with total LNG fuel (tons) consumed to reach the net values (IMO, 2009). The Figure 4.7 depicts the total CO<sub>2</sub> emissions from the round voyage between the mentioned ports.

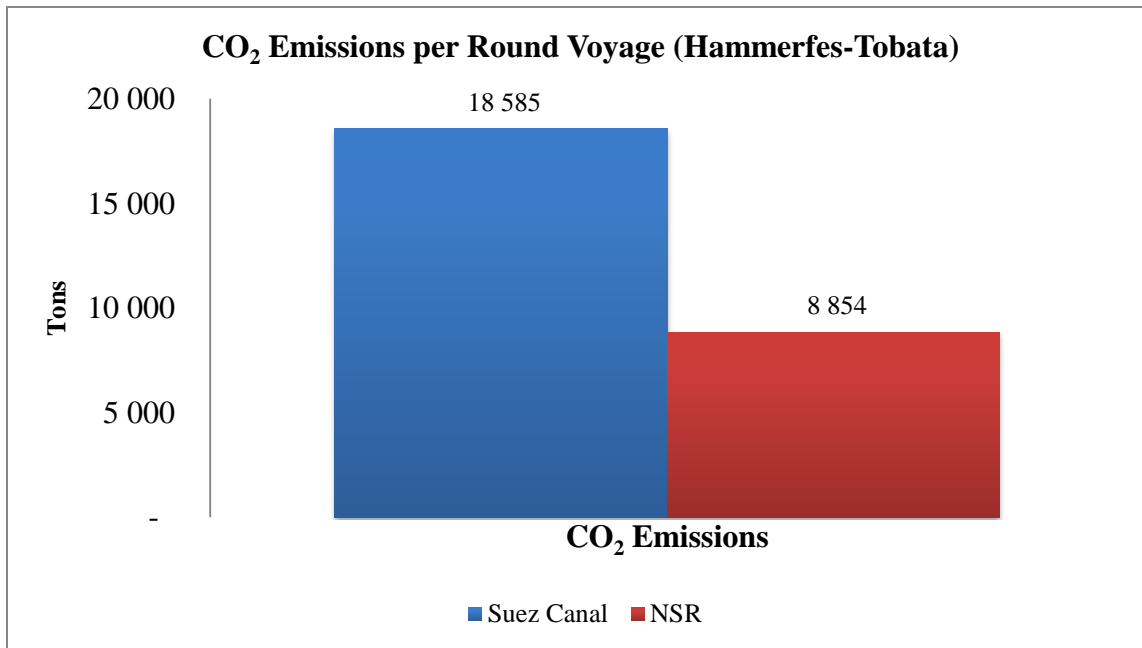


Figure 4.3: CO<sub>2</sub> emission comparison of LNG shipping via NSR and via Suez Canal

The above figure 4.3 demonstrates that NSR navigation for a round trip between Hammerfest and Tobata is more environmental friendly in terms of CO<sub>2</sub> emissions in comparison to the same voyage through the alternate route of Suez Canal. The LNG carrier traversing the NSR between the mentioned ports emits 9,731 tons less carbon dioxide and thus is 52 % efficient over the Suez Canal route. In practice, the vessel may use the heavy fuel oil on her ballast trip that will affect the total CO<sub>2</sub> emissions.

Summing up on the above table and figures, the NSR navigation appears more efficient in terms of fuel consumption, CO<sub>2</sub> emissions and reduced sailing days for the LNG carrier sailing between Norway and Japan under the given conditions.

#### 4.4 Shipping Cost per Round Voyage

The international flow of gas and varying global gas-pricing structure largely depends on the LNG shipping cost. Over the last couple of years, LNG shipping costs have considerably been an important factor in deciding the LNG cargo destinations. The LNG shipping costs also play a crucial role to understand the future global prices of gas (TimeraEnergy, 2013)

This section aims to explore that how the shipping routes affect the per ton LNG shipping cost. The table 4.3 investigates and compares the LNG shipping cost components for the two alternate shipping passages namely the Northern Sea Route and Suez Canal.

#### **Cost Comparison of a round trip through the Suez Canal & NSR (Hammerfest, Norway-Tobata, Japan)**

<b>Cost Components</b>	<b>Suez Canal</b>	<b>NSR</b>
Vessel charter cost per round voyage (\$)	7 396 700	3 735 400
Total Fuel Cost (\$)	3 433 700	1 635 710
Canal tariff per round voyage (\$)	1 71 693	8 07 975
Additional piracy insurance in Suez Canal per round voyage	1 58 204	

Additional insurance premium for Increased Values (IV) in NSR (\$)		20 250
Additional H&M insurance for NSR navigation (\$)		2 81 250
Total Costs per round voyage (\$)	11 160 297	6 480 585
Total Savings (\$)	4 679 712 (42%)	
Cost per ton (\$) (1MMBtu = 0.0192ton)	165 \$ /ton (3.2 \$ / MMBtu)	96 \$ / ton ( 1.8 \$ / MMBtu)
Savings per ton (\$)	69 \$ / ton (42%)	

Table: 4.3 Cost Comparison of a round trip through the Suez Canal & NSR

In the table above, the major LNG, shipping cost components are calculated and compared in accordance with the experts' opinions and market information. Based on these cost components the total shipping cost per round voyage and per ton between the assumed ports is calculated.

The cost components presented in table 4.3 are commented as under;

### **Chartering cost**

This is the cost incurred to secure the shipping capacity by chartering a vessel. The shipping capacity on an LNG carrier can be accessed in different ways, such as using own vessel, making the time charter fixtures or by using the single or spot charters. For the calculations in table 4.3, the spot charter rate is used to calculate the total charter cost for the voyage. The spot charter rates are comparatively higher and more instable in relation to long-term charter rates (Rokstad, 2013; Timera Energy, 2013).

The spot charter rate in the calculation above covers the capital cost including and the vessel running cost, excluding the extra insurance premiums for both routes and the voyage costs that are mentioned separately in the calculations. As discussed earlier that the spot charter rate is relatively volatile and it depends on various factors such as vessel availability, natural gas

production levels, oil and gas prices, long term charter agreements, deregulations of gas markets in Europe and US, world economic growth , competition for alternate energy sources et cetera(Drewry, 2006; Dahl, 2013).

The spot charter also varies for steam vessels and DFDE vessels, since the vessel in the study is a DFDE, therefore, the current spot rate that is 95 000 is used for both route calculations (Platou, 2013). In the current market situation, the spot rate would almost be same disregarding the sailing route choice for the vessel (Rokstad, 2013; Dahl, 2013). The total charter cost for a round voyage is derived by multiplying the charter rate with the number of sailing days for each route that is 19.66 days via the Northern Sea Route and 39.93 days via the Suez Canal.

Three cost components make the vessel's total voyage costs, which are the fuel cost, canal cost and the port charges.

### **Fuel Cost**

The bunker expenditures are the second largest cost component after the chartering cost, in the overall shipping cost structure. The bunker price varies from region to region around the globe (TimeraEnergy, 2013).Bunker prices may change in future but these calculations are made according to the current approximate rates. The fuel cost calculations are elaborated in the section above 4.3.

### **Canal Costs**

The commercial vessels making a cross continental voyage between Europe and Asia, are required to pay the canal tariff. If the vessel navigates via Suez Canal for reaching to Tobata from Hammerfest, it is subject to the Suez Canal fee and conversely if it takes the NSR for the transit voyage, the NSR service charges are applied.

Suez Canal has its own unit for ship measurement, namely the Suez Canal Net Tonnage (SCNT). Against this measure, tolls are calculated in special drawing rights (SDR). LNG carriers avail 35 percent discount on the total Suez Canal fees, and the due to the lower tonnage the membrane LNG vessels pay less in terms of transit dues in comparison to the Moss type LNG vessels (Drewry, 2006). The Suez Canal cost for this study is calculated by using the Suez Canal



Authority (SCA, 2013) calculator and a 35 percent rebate (Drewry, 2006) is deducted from the total fee.

The Northern Sea route is partly covered by ice, consequently the vessel navigating the NSR needs the icebreakers' assistance. The Russian authorities charge this fee for the icebreakers service. The NSR toll secures access to different services such as, icebreaker support, maintenance of the passage, reconnaissance flights, satellite communication, pilotage, meteorological service et cetera. The NSR fee mainly depends on the vessel particulars for instance the vessel and cargo type, ice class, size, ice conditions and crew experience et cetera (Østreng et al., 2013)

The NSR fee for this particular LNG transit voyage is obtained from an arctic shipping expert, as there was not specific information in the literature. According to Falck (2013) for the laden voyage the NSR fee is 6.80 US dollars per ton cargo loaded and for the ballast voyage the rate is 3 US dollars per ton of vessel's full displacement (Falck, 2013)

### **Port Charges**

The last and most complex voyage cost is the port charges. Port charges cover various small cost components, and some of these port charges are paid by the cargo owners and rest by the charterer (Drewry, 2006). For the calculations in this study port charges are assumed similar for both routes, and therefor are not included in the table 4.3.

### **Insurance**

A vessel can face several risks during the navigation. Marine insurance generally provides the coverage against the insured risks. The marine insurance for the vessels navigating along the NSR is a critical factor to be considered, when making such calculations for a transit voyage. The extra insurance premiums for sailing along the NSR may increase the overall shipping cost. Marine insurance is comprised of three different covers, the first cover in this respect is Hull and Machinery insurance (H&M) of the vessel itself, the second is concerned with the risk imposed to others by the vessel operations, and the final provides insurance coverage against the damage to the cargo (Mulherin, 1996).

The marine insurance of a vessel depends on multiple factors such as the vessel's gross tonnage, the insured value of the vessel, time of sailing and climatic conditions, vessel's owners' historical record, the competition level in the insurance market (Mulherin, 1996)

The P&I insurance covers an extensive range of liabilities such as personal injury to the vessel crew, passengers or any one on board the vessel, cargo loss or damage, oil pollution, wreck removal and dock damage (Østreng et al., 2013)

Underwriters do not charge extra P&I insurance premium for the transarctic shipping between Europe and Asia, via the NSR, as verified by (Gard, 2013) and (Skuld, 2013). Since the P&I cover is the same for the shipping through the northern and southern routes, therefore it is not taken into account for the shipping cost calculations in this study.

Only the Hull and machinery insurance and insurance for increased values (IV) for the NSR shipping is added in the calculations. The total insured value of this ice classed LNG carrier is 2 25 000 000 USD that is split into the Hull & Machinery and Increased Value (IV). The vessel owners install various types of additional equipment on board for sailing through the NSR; there is extra insurance for such equipment namely the increased values (IV), mentioned by an underwriter. One of the largest marine underwriters provided the additional insurance figures for this particular LNG vessel that is assumed in the study. The name of the underwriter and the insurance calculation method for this vessel is treated as confidential in this study.

The additional insurance cost for this vessel subject to certain assumptions.

*“The first and foremost condition is that the voyage is made in good ice conditions. The vessel must use the icebreaker or ocean-going tug services during the voyage. The vessel must follow the ice breakers at a safe distance at least more than 1 meter for waters shallower than 30 meters and greater width if breaking solid sea ice, than the vessel conducting the voyage at all times in the excluded area. In case of any incident, the underwriter must be informed immediately for any claim under the H&M or IV policy”*

According to (Gard, 2013) the Norway based marine underwriter, the insurance plays a minor role in the overall cost picture of the arctic shipping. In future, if the ice-conditions are favorable and the sufficient search and rescue facilities are provided along the NSR, the underwriters

would most likely not charge any additional premiums for the transit shipping through the NSR. Most of the insurance premium is not related to the ice but to the remoteness of the area, because any incident can bring huge loss. The political uncertainty is also another critical factor that can hamper the process of claims handling in case of any contingent situation. Shipping through the NSR is relatively new type of trade, and the risk / price is not yet fully established. There may be huge variations in the future insurance premiums for arctic shipping depending on the incidents and how they are dealt with, because currently due to only few voyages through this route no any reliable statistics is available yet (Gard, 2013)

For the quality check, the researcher sent these cost calculations via email to (Falck, 2013) who is an expert in an arctic shipping company. Falck (2013) highlighted that due to piracy in the Gulf of Aden the insurance cost for transit shipping through the Suez Canal has increased and therefore, it should also be considered for shipping cost comparisons.

The same anonymous underwriter, who provided the H&M and IV insurance figures for the vessel, indicated the extra piracy insurance cost for the transit shipping via the Suez Canal.

The piracy insurance for Suez Canal trip covers the round voyage between the studied ports, and subject to certain assumptions.

*“The price of armed guards and kidnap and ransom premium is unknown for this vessel, but if the ship owner buys such services, he will get rebate on the war premium. Ship owner do not buy the loss of hire insurance for this voyage. It must be ensured that the vessel passes through the Internationally Recommended Transit Corridor (IRTC) as part of Gulf of Aden Group Transit (GOA GT) and the vessel / owner is registered with Maritime Security Centre Horn of Africa (MSC HOA) and to follow recommended Best Practice (BMP 4). The additional discount for K&R is warranted that a K&R policy is in place with ransom and cost limits of (minimum) USD 5 million and containing full waiver of subrogation against War Risks underwriters. The vessel is subject to 48 hours’ notice / 7 days cover and warranted no arms, or ammunition or military equipment as cargo on board, and subject to the Sanction Limitation and Exclusion Clause (JW2010/004)”*

The total shipping cost for the LNG transit voyage between Hammerfest and Tobata via the Northern Sea Route is lower than the shipping cost for the Suez Canal transit, under the

mentioned assumptions of this study. The per ton LNG shipping cost is 96 and 169 US dollars for the NSR and the Suez Canal, that gives a saving of around 42 percent for sailing through the NSR with the given conditions. One MMBtu is equivalent to 0.0192 ton, based on this the LNG cost per Million British thermal units (MMBtu) is calculated, that is considerably lower for the NSR transit in comparison to Suez Canal.

The cost components discussed in the table 4.3, are also demonstrated in the following figure to provide a better understanding of the cost comparison of both routes for this particular LNG transit between Hammerfest and Tobata.

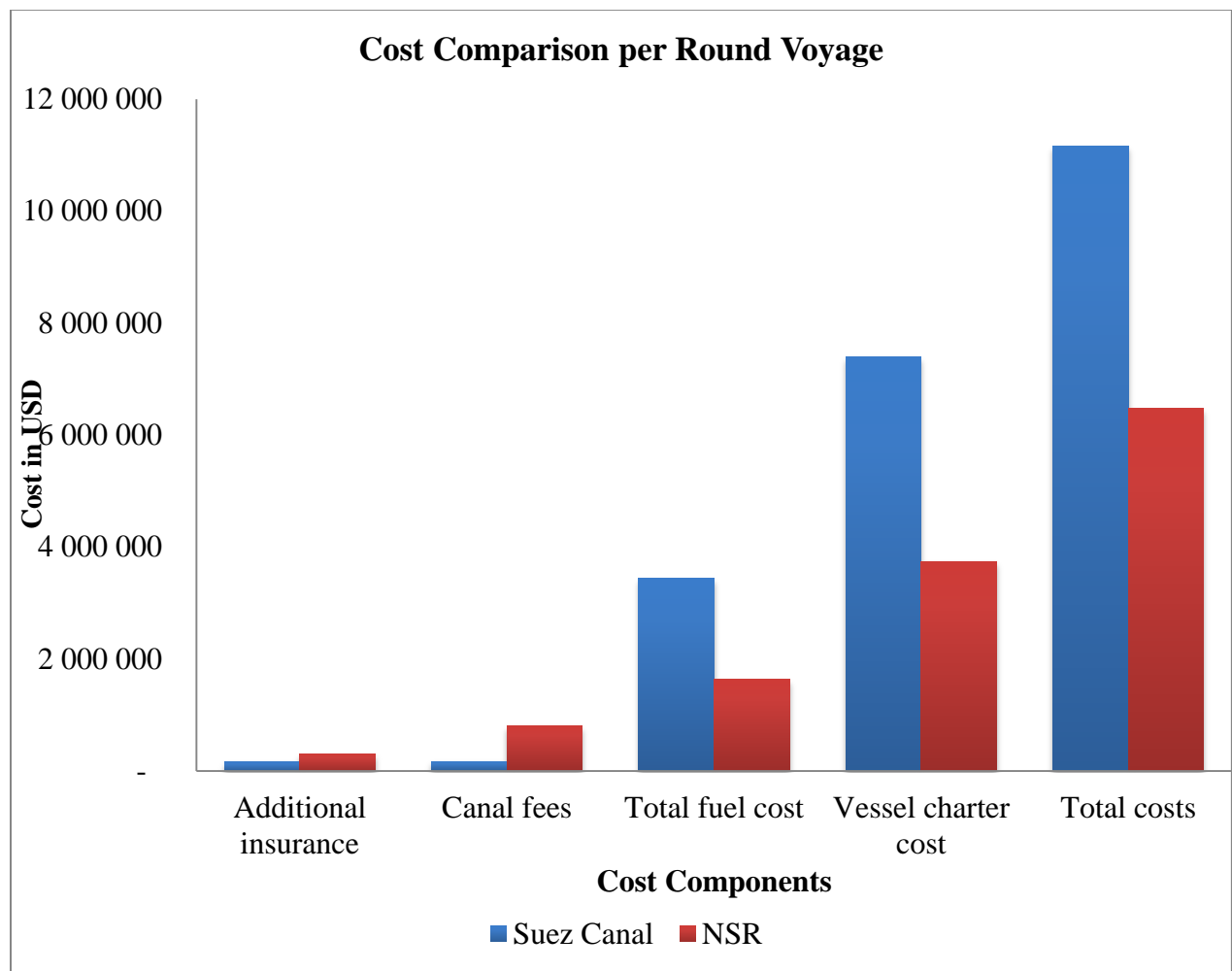


Figure 4.4: Cost Comparison of a round trip through the Suez Canal & NSR

The figure 4.4 shows that the vessel chart rate and the fuel cost make the largest components of the shipping cost for this voyage, these costs are around 50% less for the NSR passage in

comparison. However, the canal fee and additional insurance, appears to as 80 % and 48% higher for the Northern Sea Route against its alternate the Suez Canal respectively for this typical LNG transit voyage between Norway and Japan under the assumed parameters.

The overall result of the shipping cost calculations demonstrates, that the NSR is around 42 percent cost efficient over its competitor Suez Canal, due to the fifty percent shorter distance between the loadings and discharging ports.

## **4.5 Sensitivity Analysis**

The sensitivity analysis is a tool that is used to evaluate, that how the variations in a certain parameter or cost component affect the overall result of any calculation. This section aims to answer the sub research question that how a variation in the key shipping cost components affect the efficiency of the NSR as an alternate to Suez Canal. There are different cost components but this section mainly considers the NSR fee and Charter Rate to assess their impact on the overall routes efficiency.

### **4.5.1 Route Efficiency and NSR Tariff**

(Liu & Kronbak, 2010) used the scenario analysis in their work to assess the impact of varying bunker prices and reduced NSR fee on the overall profitability of the container service between Europe and Asia.

In the decade of 1990, the NSR tariff was increased by 50 percent after the decline of cargo trade volume through the passage because the icebreaker operations became unprofitable for the Russian state. Earlier in 1990, the NSR fee rate was 2-4 USD per ton of container cargo, which reached to 7.5 USD in late 1990. When the Russian state cut the subsidies on the icebreaker services in 2003, the NSR fee jumped dramatically to 23 USD per ton of cargo and the current fee is about 40 USD per ton of container cargo (Liu & Kronbak, 2010; Østreng et al, 2013). Østreng et al (2013) argues that the NSR fee seems negotiable because the back in 2009, Beluga shipping paid only 2.25 USD per dead weight for the project cargo and in future, the NSR may be navigated without the icebreakers assistance when the ice will vanish away.

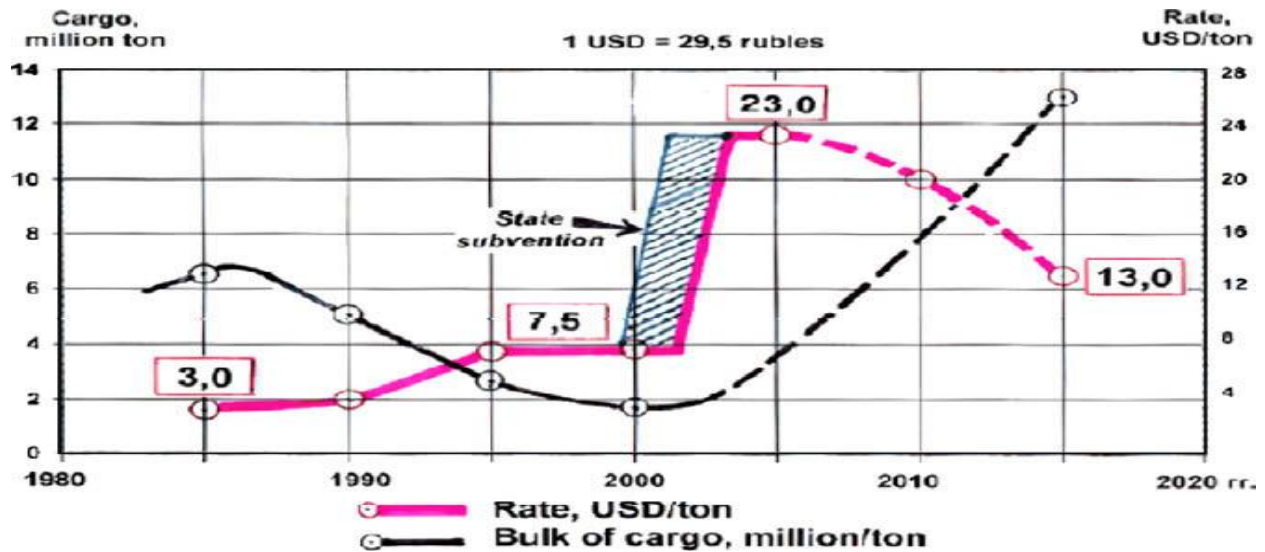


Figure 4.5: The past and expected future developments in the NSR tariff (Liu & Kronbak, 2010)

The figure 4.9 shows the relationship between the cargo trade volumes and the tariff fee, when the cargo trade was huge along the route the fee was lower but with a decline in cargo traffic through the cargo per ton tariff also jumped upward. (Vukmanovic & Koranyi, 2013) write that Russian authorities have shown intentions to reduce the transit fee to attract more cargo and investments. In future, the increasing traffic through the route may play its role in bring the tariff down.

There are certain significant factors that will determine the future NSR fee for the transit vessels, such as amount of cargo volume, the Russian economy and the state policy for the promotion of the Northern Sea Route (Liu & Kronbak, 2010)

In the total cost calculations of this study, the NSR fee appears as a significant component that is around 80% higher than the Suez Canal fees. The table 4.4 demonstrates that if the NSR tariff is reduced how it will affect the total shipping cost per ton of LNG cargo. In the table 4.4, total cost is calculated against the three levels of reduced NSR fee.

### Routes Competitiveness at varying NSR tariff levels

Cost	Suez Canal	NSR
<i>NSR fee = 50% reduction</i>		
Total Costs per round voyage(\$)	11 160 297	6 076 597
Total Savings (\$)	5 083 700 (45%)	
Cost per ton (\$)	165\$/ton	90\$/ton
Savings per ton (\$)	75\$/ton (45%)	
<i>NSR fee= 85% reduction</i>		
Total Costs per round voyage (\$)	11 160 297	5 793 806
Total Savings (\$)	5 366 491(48%)	
Cost per ton (\$)	165\$/ton	86\$/ton
Savings per ton (\$)	79\$/ton (48%)	
<i>NSR fee= 100% reduction</i>		
Total Costs per round voyage (\$)	11 160 297	5 672 610
Total Savings (\$)	5 487 687 (49%)	
Cost per ton (\$)	165\$/ton	84\$/ton
Savings per ton (\$)	81\$/ton (49%)	

Table 4.4: Routes competitiveness at varying NSR tariff levels

The table above shows that a future reduction in NSR fee will increase the competitiveness of the route as an alternate to Suez Canal. The table 4.4 reflects that more low the NSR fee is the more competitive the route is with given stated conditions.

The figure 4.10 reflects the per ton cargo cost against the varying toll levels;

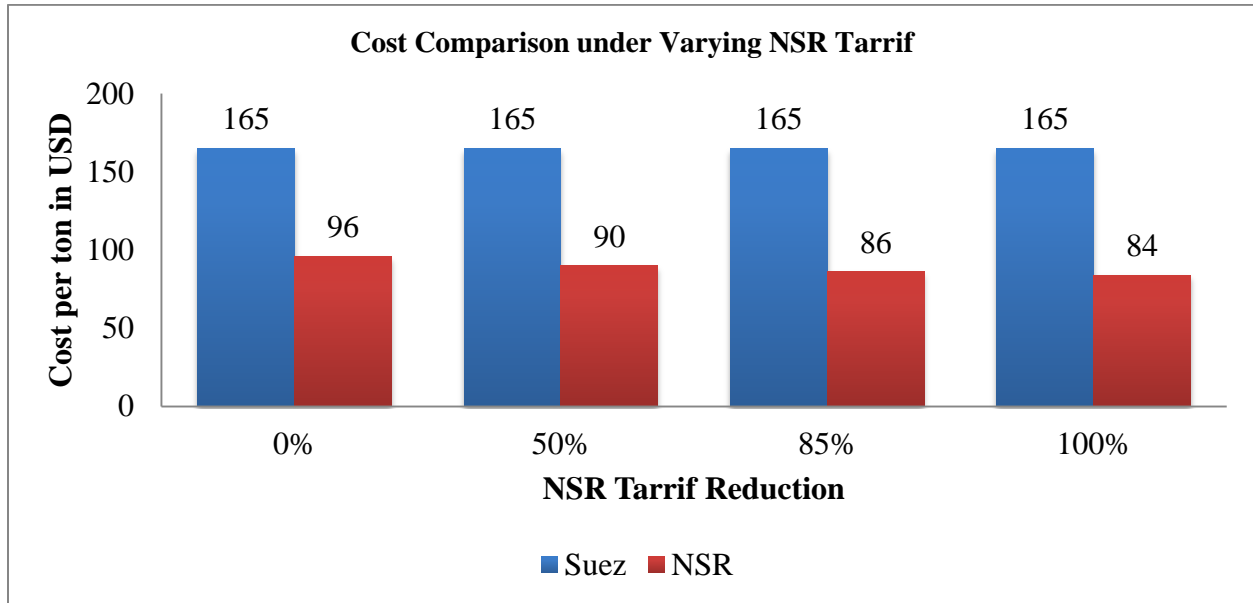


Figure 4.6: Impact of NSR tariff rate on the per LNG cargo cost

It is quite visible from the above figure 4.10 that the NSR tariff will affect the per ton LNG shipping cost at a nominal rate. The 0% NSR tariff reduction represents the current rate in the figure 4.6 a reduction in the toll by 50 % will save more \$6 per ton of LNG shipping cost for NSR transiting and a 100% can increase the NSR cost efficiency potential by 12 USD per ton in relation to the current rate.

#### 4.5.2 Route Efficiency and Charter Rate

Falck (2013) indicated that the charter rate per day is the most influential cost component that may alter the total cost picture for the transit shipping through the NSR as an alternate to the Suez Canal. As discussed earlier that the spot charter market is highly volatile and the per day spot charter rate fluctuates quite frequently. The charter market has seen a quite diversified trend in the day rate over the last few years, the charter rate was as lower as 20 000 USD per day and as high as 150 000. The year 2012 was important for the charter market because per day rate was at its highest level in the last thirteen years, See figure 4.11



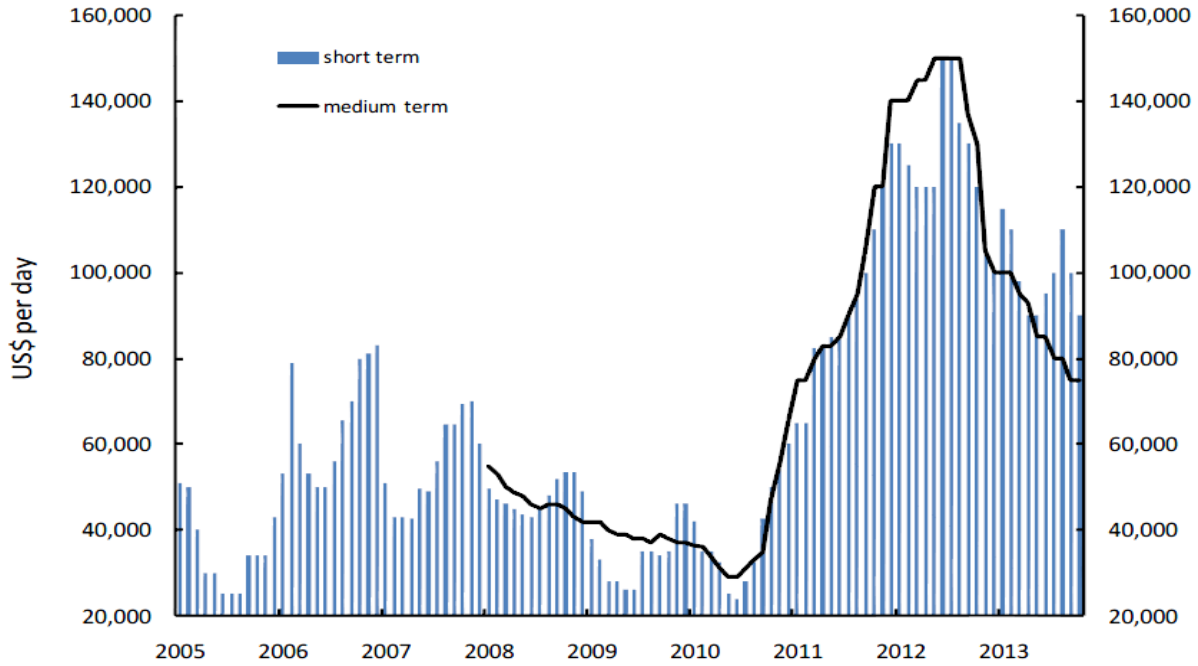


Figure 4.7: Day charter rate history for DFDE LNG vessels (Platou, 2013)

Keeping the market trends in mind three different charter rates low (35 000), medium (75 000) and high (1 50 000) are used to evaluate the influence of the charter market on the routes competitiveness. See table 4.5

### Route Competitiveness at varying Charter Rates

Cost	Suez Canal	NSR
<i>Low Charter Rate = 35 000 \$ / day</i>		
Total Costs per round voyage(\$)	6 488 697	4 121 385
Total Savings (\$)	2 367 312 (37%)	
Cost per ton (\$)	96\$/ton	61\$/ton
Savings per ton (\$)	35\$/ton (37%)	
<i>Medium Charter Rate = 75 000 \$ / day</i>		

Total Costs per round voyage (\$)	9 603 097	5 694 685
Total Savings (\$)	3 908 912 (41%)	
Cost per ton (\$)	142\$/ton	84\$/ton
Savings per ton (\$)	58 (41%)	
<i>High Charter Rate = 1 50 000 \$ / day</i>		
Total Costs per round voyage (\$)	15 442 597	8 643 185
Total Savings (\$)	6 799 412 (44%)	
Cost per ton (\$)	229\$/ton	128\$/ton
Savings per ton (\$)	101\$/ton (44%)	

Table 4.5 Route competitiveness at varying Charter Rates

The table above shows that the charter rate has a strong impact on the shipping cost of LNG cargo through both the passages. At the low charter rate, the northern sea route is not as attractive as it is at the higher charter rate in terms of cost efficiency, which is 37 % and 44 % for low and high rates respectively with the stated assumptions of this study.

Based on the table 4.5 the following chart is plotted to see the comparative effect of the charter rate on the per ton LNG shipping cost. (Figure 4.12)

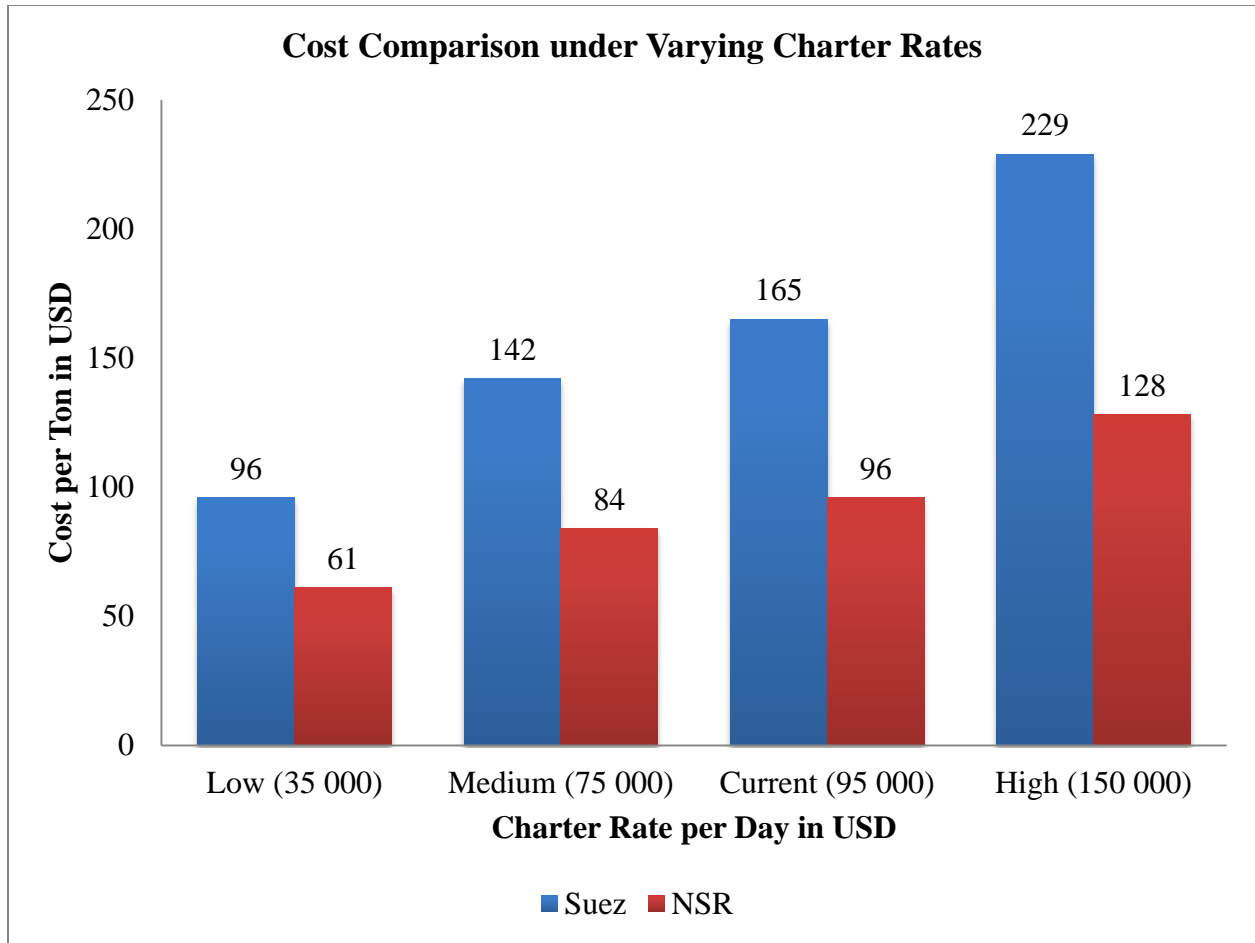


Figure 4.8: Cost Comparison of both routes under varying Charter Rates

The figure 4.8, presents the per ton LNG shipping cost at four different charter rates for the Northern Sea route and Suez Canal. A low charter rate (35 000) gives a saving of 35 dollars and at the higher rate (1 50 000) per ton saving reaches to 101 dollars accordingly. The trend of the charter rate in the figure 4.8 shows that the higher charter rate would result in larger savings by sailing through the NSR.

Under the certain assumptions, the comparisons demonstrate that the Northern Sea route is cost efficient in both the mentioned scenarios for the LNG transit shipping between Norway and Japan over the alternate route of Suez Canal due to the shorter distance. Higher charter rate per day will enlarge the cost saving potential of the Northern Sea Route.

## 4.6 Research Findings

This section aims to present the findings that are drawn out based on the literature review and the case study conducted in the previous chapter. The most relevant outcomes with respect to the research question of this study are described in the following.

Thawing ice in the arctic has unlocked new opportunities for the shipment of liquefied natural gas (LNG) by providing a comparatively shorter transit route of NSR between Europe and Asia. The distance saving capacity of the NSR over the Suez route is around fifty percent for the LNG transit trips between north European and north Asian ports. In comparison to the traditional route of Suez Canal, the Northern Sea Route appears as forty two percent more cost efficient passage, and it has the potential to save about 4.7 million US dollars for a full round voyage of an LNG tanker navigating between Europe and Asia. This may attract the maritime actors to make the required investments (See table 4.3 & figure 4.4). There are also certain perils and uncertainties in the smooth commercial LNG shipping operations on yearly basis along the NSR, and in present, merely the seasonal LNG shipping is possible through the NSR.

The charter rate per day seems to be the most important and largest cost component in the total shipping cost picture, and a higher charter rate increases the cost efficiency of the Northern Sea Route over the Suez Canal for the transit shipping of LNG between the northern ports of Europe and Asia. The insurance cost seems to have relatively less impact on the overall cost structure of the transit shipping via the NSR and Suez Canal, and a reduced canal tariff would increase the competitiveness of Northern Sea Route (See table 4.4 & 4.5). It was found that the regional price differences of LNG in Asia, Europe, and United States would also play a remarkable role in deciding the fate of Northern Sea Route, up to a certain extent.

In the present era, there is an extensive legislation to curb the global greenhouse gas (GHG) emissions, and the carbon dioxide (CO<sub>2</sub>) appears as the predominant gas of all the existing GHGs. The Northern Sea Route emerges as a possible solution to curtail the CO<sub>2</sub> emissions from shipping activities, and the CO<sub>2</sub> emission from an LNG vessel sailing between northern Europe and northern Asia via the NSR is about fifty two percent less, than the vessel going through the longer passage of Suez Canal(See table 4.2 & figure 4.3). The shorter distance leads to lower

fuel consumptions that result in lower CO<sub>2</sub> emissions. The transit shipping through the NSR may also pose a threat to the local habitat of the arctic region in the due time.

Russian gas companies primarily will benefit from the Northern Sea Route, because of proximity to the largest gas consumption hubs. Due to the intensive gas demand in Asia, huge LNG deliveries are expected from Yamal and Shtokman gas fields to make their way through the Northern Sea Route in the future. Japan appears as a largest LNG consumer on the map and it may emerge as a largest user of the NSR to meet its growing energy needs due to shutdown of its nuclear power plants. The lack of icebreakers and a scanty fleet of standardized ice classed vessels may delay the early LNG transit operations across the NSR.

The shale gas revolution and American desire to be self-sufficient in gas production over the next couple of decades may curtail the future LNG imports from Norway. Norway may look for new customers in the Asian market to enjoy the high LNG price there. The Northern Sea Route has increased the competitiveness of Norwegian LNG in the Asian market, and already a few of world's first LNG cargo deliveries through the NSR have found their origin in Norway.

Political turmoil in the Middle East and piracy threat in the Gulf of Aden may increase the attractiveness of the NSR for the prospective LNG shipping.

The retreatment of ice in the northern hemisphere has grabbed a huge international interest. China appears to make enormous investments in the exploration of arctic hydrocarbons and this is likely to accelerate the use of Northern Sea Route in the coming years.

In future, Northern Sea Route will not emerge as a huge competitor to the southern route of Suez Canal, but instead it may take away merely a part of the shipping, mainly the hydrocarbons and bulk that goes through the Suez Canal today, because the Suez Canal too is a shortcut for some ports and cargo trades.

## 5. Discussion

Due to global warming the drastic thaw of ice along the northern archipelagos of Russia has carved a shortcut sailing route of NSR between the Atlantic and Pacific oceans, the ice melt has increased the possibilities to explore the untapped hydrocarbons in the arctic to meet the future energy needs. The global energy demand is projected to upsurge in the coming years and Asia may appear as a largest energy consumer on the map. The liquefied natural gas (LNG) appears to be the fuel of the future, but the production of cheap shale gas in the American continent has altered the global geopolitics of energy and it may curb the LNG deliveries from the north European gas terminal in the coming years.

In 2012, 19 000 vessels navigated through the Suez Canal and 46 vessels including the world's first LNG vessel Ob River, made their way via the NSR, and that reveals a remarkable difference in the use of both passages.

In the recent years, NSR has got considerable attention from the actors in the maritime industry. Several research studies were carried out to assess the commercial potential of the NSR as a competitor to the Suez Canal; the container-shipping segment was the primary focus of the earlier research studies in this respect. There is no any research study in the existing pool of literature, which enlightens the economic and environmental aspects of LNG transit shipping through the NSR.

The main objective of this research was to investigate the potential of the Northern Sea Route in terms of shipping cost and CO<sub>2</sub> emission efficiency for the LNG transit shipping through the Northern Sea Route as an alternate to Suez Canal.

In the first chapter the introduction and background of the study was presented, followed by the second chapter that reviews the relevant existing literature. The chapter three focused on the methodology pursued in the study to reach the research goal and the case study method was selected to meet the research goal, this section also addresses the quality aspects of this report. In the subsequent section, a case study was conducted to answer the main research question that is repeated as under;

*‘How much is the economic potential of using the Northern Sea Route as an alternate to the Suez Canal for LNG transportation between Europe and Asia and how the NSR can assist to gain the environmental sustainability in respect of CO2 emissions?’*

The case study compared the key shipping cost components related to an LNG carrier navigating between Hammerfest, Norway and Tobata, Japan, via the NSR and Suez Canal. The total CO<sub>2</sub> emissions from the assumed vessel were also evaluated to determine the environmental efficiency of NSR over the Suez Canal.

The values used in the case study for calculations, primarily based on the data obtained from shipping professionals, underwriters, fuel experts, charterers and shipping agents by using the multiple modes of interview, the calculations are supported by the existing literature.

A sensitivity analysis was performed to identify the impact of variation in the charter rate and the reduced NSR fee on the routes efficiency.

This research also examined that how a shift in the trading patterns of LNG, the discovery of new gas reserves in the arctic waters and production of shale gas will influence the prospective use of Northern Sea Route.

A number of research studies (Schøyen & Bråthen, 2011; Liu and Kronbak, 2010; Østreng et al, 2013; Kitagawa, 2008, Ragner, 2000) described that the NSR offer a shorter route between Europe and Asia for the certain ports over the Suez Canal. Falck (2013) indicated that the distance saving between the ports located in northeast Asia and northwest Europe is 50 percent over the Suez Canal.

In this research, it was found that distance saving capacity of the NSR over the Suez route is around fifty percent for the LNG transit trips between north European and north Asian ports.

According to the investigation of (Schøyen & Bråthen, 2011; Østreng et al, 2013) and (Furuichi & Otsuka, 2013) the seasonal shipping operations along the NSR over the Suez Canal are profitable for the bulk and container cargo trades under the certain assumptions.

This research explored that, in comparison to the traditional route of Suez Canal, the Northern Sea Route appears as forty two percent more cost efficient passage, and it has the potential to

save about 4.7 million US dollars for a full round voyage of an LNG tanker navigating between Europe and Asia. This may attract the maritime actors to make the required investments (See table 4.3).

(Schøyen & Bråthen, 2011) in their research made the shipping cost comparison for a single leg trip from Norway to China. (Falck, 2013) argued that this type of cost comparison must always be made on round voyage basis, otherwise it would give a wrong indication. Therefore, in this research cost comparison for the vessel navigating between Europe and Asia is made for the full round voyage and thus this research may oppose the study of (Schøyen & Bråthen, 2011) in this respect.

(Schøyen & Bråthen, 2011) assumed a 20% additional charter rate for the ice classed vessels in their study, (Dahl, 2013) and (Rokstad, 2013) revealed that the charter rate would be similar for the ice classed vessels and ordinary vessels. Based on (Dahl, 2013; Rokstad, 2013) this research may disagree with the assumption made by (Schøyen & Bråthen, 2011) regarding the charter rate per day for the cost calculations.

The research found that the charter rate per day seems to be the most important and largest cost component in the total shipping cost picture. Falck (2013) claimed that the charter rate affects significantly the cost efficiency of the routes. It was discovered that against the low charter rate per day, the higher charter rate increase the cost efficiency of the Northern Sea Route over the Suez Canal for the transit shipping of LNG between the northern ports of Europe and Asia (See table 4.5)

Calculation of additional insurance premium for the shipping through the NSR appears to be a hard task and it depends on multiple factors. The insurance cost seems to have relatively less impact on the overall cost structure indicated by (Gard, 2013).

Liu and Kronbak (2010) in their work suggested a 25 percent increased protection and indemnity (P&I) insurance premium for the ice-classed vessels. Furuichi & Otsuka (2013) in their investigation used 10 dollars per gross tonnage per year as additional H&M and P&I insurance premium for the vessels crossing the NSR. Marine underwriters (Gard, 2013; Skuld, 2013) indicated that they do not charge extra P&I premium for the NSR shipping and therefore this



research may falsify the assumption made by the (Liu and Kronbak, 2010 and Furuichi & Otsuka, 2013).

The vessels navigating through the Suez Canal face a piracy threat and that has increased the insurance cost, indicated by (Furuichi & Otsuka, 2013; Falck, 2013) and an anonymous underwriter. Liu and Kronbak (2010) and Schøyen & Bråthen, (2011) did not include the additional piracy insurance cost in their investigations, that may weaken the results of their studies.

The regional price imbalance of LNG in Asia, Europe, and United States will also play an integral part in deciding the fate of Northern Sea Route, up to a certain extent. The NSR may be used to exploit the higher gas price in Asia through a fifty percent shorter route in the near future, but the prospective extra gas supplies to Asian market may reduce the price imbalance in the gas market (Falck, 2013; Dreyer and Stang, 2013).

(Liu and Kronbak, 2010; Schøyen & Bråthen, 2011; Furuichi & Otsuka, 2013; Østreng, 2013) advocated that due to the shorter transit distance between Asia and Europe through the NSR the lower fuel consumption results in declined CO<sub>2</sub> emissions. This research proved that Northern Sea Route emerges as a possible solution to curtail the CO<sub>2</sub> emissions from shipping activities, and the CO<sub>2</sub> emission from an LNG vessel sailing between northern Europe and northern Asia via the NSR is about fifty two percent less, than the vessel going through the longer passage of Suez Canal(See table 4.2). The shorter distance leads to lower fuel consumptions that result in lower CO<sub>2</sub> emissions.

The transit shipping through the NSR may also pose a threat to the local habitat of the arctic region in the due time.(Peters et al., 2011 ), (Liu & Kronbak, 2010) and (Østreng, 2013) explained that the transit shipping via the NSR will accelerate the local emissions of CO<sub>2</sub>. In practice, the DFDE LNG carriers use the heavy fuel oil (HFO) on the ballast leg when there is no cargo onboard, that would increase the amount of CO<sub>2</sub> emissions((Lauritzen, 2013).

(Liu & Kronbak, 2010) in their investigation about the economic feasibility of NSR conducted a scenario analysis where they found that a reduced NSR fee would increase the efficiency of the NSR over its rival the Suez Canal. This research proves their finding about the impact of NSR

fee on the route's competitiveness. It was examined in this research that a reduced NSR fee increase the cost saving potential for the vessels traversing the NSR (See table 4.4)

Østreng, (2013) and Gunnar Sander according to Nilsen, (2012) explained that the revolution of shale gas has affected the gas market, and Norway may have to look for new customers to sale its output. (Dreyer & Stang, 2013) report that since the shale gas boom in 2007 the US imports of natural gas declined by around 5.5% between 2007 and 2010. Østreng (2013) indicate that US vision to be energy self-sufficient is likely to realize and it may deliver gas to its allies Japan, South Korea, and China in the future.

The research finds that the shale gas revolution and American desire to be self-sufficient in gas production over the next couple of decades may curtail the future LNG imports from Norway. Norway may look for new customers in the Asian market to enjoy the high LNG price there. The Northern Sea Route has increased the competitiveness of Norwegian LNG in the Asian market, and already a few of world's first LNG cargo deliveries through the NSR have found their origin in Norway.

(Nilsen, 2012; Lauritzen, 2013; Østreng et al, 2013) argue that the lack of icebreakers and ice classed LNG vessels is a big challenge and it may affect the early commercial use of NSR for the LNG shipping. (Vukmanovic & Koranyi, 2013) report that the current icebreakers fleet is comprised of only 10 to 15 icebreakers and that reach the age of retirement by 2017. The total world fleet of LNG tankers contains 359 LNG vessels, and out of this, only few LNG carriers are able to sail in the ice-infested waters along the NSR. The research has found that the availability of the ice-classed fleet of LNG carriers and icebreakers is an obstacle in the efficient transit shipping operations via the NSR in the short run.

Extensive ice along the passage, Russian militarization, lack of required infrastructure, and politics is some of the major challenges that may prevent the actors in the LNG industry from making huge investments in the ice-classed vessels. In present, the LNG companies are reluctant to navigate via the NSR. In future, Northern Sea Route will not emerge as a huge competitor to the southern route of Suez Canal, but instead it may take away merely a part of the shipping, mainly the hydrocarbons and bulk that goes through the Suez Canal today, because the Suez

Canal too is a shortcut for some ports and cargo trades. (Dahl, 2013; Østreng, 2013; Lauritzen, 2013)

## **5.1 Research Limitations**

This research was intended to conduct an empirical study and the primary data obtained from underwriters, fuel engineers, charterers, arctic shipping professionals, and the industry experts has mainly been relied on to make shipping cost calculations, as there was not any specific and relevant data in the existing literature. The viewpoint of concerning gas companies such as Gazprom and Statoil that may use the NSR in the future is unknown as all the efforts to contact to them went unattended in this respect.

Another limitation of this research is that the vessel is assumed to use the boil of gas as a bunker fuel on the ballast leg but in reality the DFDE LNG vessels burn heavy fuel oil when they do not have cargo on board and this may alter the value calculated in respect of CO<sub>2</sub> emissions. Similarly, the vessel speed, insurance cost and fuel consumption depends on multiple factors and it may vary from case to case.

The distance in ice water of NSR is stipulated 2 880 nautical miles but in practice it may vary depending on the ice conditions and route choice.

This research considers only a single vessel operating between specific ports, which may restrict the scope of this study.

Although it is hard to generalize the inferences from a single case, but some of the findings of this study can be generalized up to a certain extent;

For instance, in comparison to the Suez Canal the NSR would offer savings in terms of fuel and charter cost between certain ports in Europe and Asia disregarding the type of the vessel, due to the shorter distance.

This study finds that due to shorter distance and low fuel consumption, the NSR contributes to reduce the CO<sub>2</sub> emissions, and this could be applied to all the vessels that can navigate the NSR.

The research reveals that there would be additional insurance for the vessels intending to traverse the Northern Sea Route no matter what type of vessel sail via this route.

It is discovered in this research, that the existing fleet of icebreakers would retire over the next few years and the lack of sufficient icebreaker presents a challenge to the future transit shipping along the NSR and this implements to all the shipping segments that may use the Northern Sea Route in the coming years.

## 6. Conclusion

The overall purpose of this research was to identify the potential of Northern Sea Route as an alternate to Suez Canal for the LNG shipping. This research also aimed to investigate the scope of NSR for the LNG shipping in respect of the energy market transitions. All to gather, two main research questions and three sub questions were formed to meet the research goals of this study. Multiple sources of evidence including research articles, reports, interviews and government documents are used to meet the research objectives.

**Research question 1:** How much is the economic potential of using the Northern Sea Route as an alternate to Suez Canal for LNG transportation between Europe and Asia?

Thawing ice in the arctic has unlocked new opportunities for the shipment of liquefied natural gas (LNG) by providing a comparatively shorter transit route of NSR between Europe and Asia. By conducting a comparative case study this research has found that the Northern Sea Route as an alternate to the Suez Canal offers reduced 50% sailing distance between the ports in Northern Europe and Northeast Asia. The cost efficiency potential of the NSR over the Suez Canal is 42% and the LNG carrier sailing between Norway and Japan offers a saving of 4.7 million dollars for a full round voyage. This may attract the industry players to make the required investments.

**Research question 2:** How does the NSR can assist to gain the environmental sustainability in respect of CO<sub>2</sub> emissions?

Currently when the environmental problem is at the top of global agenda, the Northern Sea Route emerges as a possible solution to curtail the CO<sub>2</sub> emissions from shipping activities. The CO<sub>2</sub> emission from an LNG vessel sailing between Northern Europe and Northeast Asia via the NSR is about fifty-two percent less, than the vessel going through the longer passage of Suez Canal. The CO<sub>2</sub> emission from the LNG carrier navigating between Northern Europe and Northeast Asia via the Suez Canal is 18 585 tons and via the NSR is 8 854 tons per round voyage.

**Research question 3:** How would any variation in the key shipping cost components influence the efficiency of the Northern Sea Route as an alternate to the Suez Canal?

This research conducted a sensitivity analysis to answer this question and it is found that the charter rate per day seems to be the most important and largest cost component in the total shipping cost picture. A higher charter rate increases the cost efficiency of the Northern Sea Route over the Suez Canal for the transit shipping of LNG between northern ports of Europe and Asia. The insurance cost seems to have relatively less impact on the overall cost structure of the transit shipping via the NSR and Suez Canal, and a reduced canal tariff would increase the competitiveness of Northern Sea Route.

**Research question 4:** How do the transitions in the energy market including the shale gas revolution affect the potential use of NSR and exports from northern gas plant?

Russian gas companies primarily will benefit from the Northern Sea Route, because of proximity to the largest gas consumption hubs. Due to the intensive gas demand in Asia, huge LNG deliveries are expected from Yamal and Shtokman gas fields to make their way through the Northern Sea Route in the future.

The shale gas revolution and American desire to be self-sufficient in gas production over the next couple of decades may curtail the future LNG imports from Norway. Norway may look for new customers in the Asian market to enjoy the high LNG price there. The Northern Sea Route has increased the competitiveness of Norwegian LNG in the Asian market, and already a few of world's first LNG cargo deliveries through the NSR have found their origin in Norway.

**Research question 5:** What is the scope of Northern Sea Route for LNG shipping?

Increased savings in terms of shipping cost, reduced sailing days Political turbulence in the Middle East and piracy threat in the Gulf of Aden may increase the attractiveness of the NSR for the prospective LNG shipping. The lack of icebreakers and a scanty fleet of standardized ice classed vessels may delay the early LNG transit operations across the NSR. . It was discovered that the regional price differences of LNG in Asia, Europe, and United States would also play a remarkable role in deciding the fate of Northern Sea Route, up to a certain extent.

In future, Northern Sea Route may not emerge as a huge competitor to the southern route of Suez Canal, but instead it may take away merely a part of the shipping, mainly the hydrocarbons

and bulk that goes through the Suez Canal today, because the Suez Canal too is a shortcut for some ports and cargo trades.

## **6.1 Future Research Directions**

Since the winter-navigation across the arctic is not possible in present and only the summer shipping operations are cost efficient, it would be interesting for the actors in the LNG industry to see that how much savings can be generated on yearly basis through the combined NSR-SCR operations. That implies if an LNGC operates via the NSR in summer and via the Suez Canal in winter, considering the total number of round voyages between two loading and receiving terminals in Europe and Asia. This type of research may assist the relevant bodies in decision-making.

This research proves that the LNG transit shipping operations via the Northern Sea Route as an alternate to Suez Canal result in huge cost savings and so far only a couple of gas companies have benefited from this shorter passage. The future research can investigate that despite the fact that NSR is profitable route today then why the industry players are reluctant to send gas cargo through this passage.

During the research, it was found that today the additional insurance for the NSR shipping is mainly related to the remoteness of the area, not to the ice. Further research is required to analyze that how the establishment of a standardized infrastructure and search and rescue facilities along the route will affect the future insurance costs for the vessels using the NSR for transit shipping. Up to what extent the insurance companies would be able to handle the claims if any incident happens in the passage, considering the political factors into account.

Norway is located at the gateway to the North East Passage; a potential research can investigate that how Norway can make the optimum use of its strategic location in respect of NSR.





## References

- AMSA. (2009). Arctic Council; Arctic Marine Shipping Assessment 2009 Report (pp. 194).
- Brigham, L. (2008). Arctic Shipping Scenarios and Coastal State Challenges. *Journal of Maritime Affairs*, 7, 477–484.
- Bunkerworld. (2013). Shipping Bunkerprices from <http://www.bunkerworld.com/prices/port/sg/sin/?grade=MDO>
- Carbonnier, J. (2013). The Melting North – a Frosty Sea Route to Asia. *Utrikesperspektiv*.
- Dahl, T. (2013). Telephone and email interview with the expert at Hoegh LNG regarding the LNG carriers market .
- Devik, K. F. (2013). Email interview with Devik who is Project Engineer /Newbuilding and Technology at Hoegh LNG, regarding the Fuel Consumption for LNG vessels.
- Drewry. (2006). Annual LNG shipping Market Review & Forecast (2006 ed., pp. 223). England.
- Dreyer, I., & Stang, G. (2013). The shale gas ‘revolution’: Challenges and implications for the EU: European Union Institute for Security Studies
- Dynagas. (n.d). Home page of Dynagas Ltd. The Northern Sea Route. from <http://www.dynagas.com/3/?page=north> (Accessed 15.11.2013)
- EIA. (2012). *Norway, country profile*. Retrieved from <http://www.eia.gov/countries/analysisbriefs/Norway/norway.pdf> (Accessed 05.07.2013).
- EY. (2013). Arctic Oil and Gas. from [http://www.ey.com/Publication/vwLUAssets/Arctic\\_oil\\_and\\_gas/\\$FILE/Arctic\\_oil\\_and\\_gas.pdf](http://www.ey.com/Publication/vwLUAssets/Arctic_oil_and_gas/$FILE/Arctic_oil_and_gas.pdf) (Accessed 01.11.2013)
- EY. (2013 b). Global LNG ; Will new demand and new supply mean new pricing? (pp. 20).
- Falck, H. (2013). Personal, email and telephone interviews with the arctic shipping expert regarding the different aspects of Northern Sea Route and Suez Canal.
- Foss, M. M. (2012). INTRODUCTION TO LNG; An overview on liquefied natural gas (LNG), its properties, the LNG industry, and safety considerations. [http://www.beg.utexas.edu/energyecon/lng/documents/CEE\\_INTRODUCTION\\_TO\\_LNG\\_FINAL.pdf](http://www.beg.utexas.edu/energyecon/lng/documents/CEE_INTRODUCTION_TO_LNG_FINAL.pdf) >(Accessed 11.11.2013)
- Furuichi, M., & Otsuka, N. (2013, 3-5 July). *Cost Analysis of the Northern Sea Route (NSR) and the Conventional Route Shipping*. Paper presented at the IAME 2013, Marseille.
- Gard. (2013). Email interview with Reidun Eikeland Haahjem an expert in Gard insurance company regarding the insurance aspects of the NSR.
- Gazprom. (2012). Gazprom successfully completes world’s first LNG supply via Northern Sea Route. from <http://www.gazprom.com/press/news/2012/december/article150603/> (Accessed 09.05.2013)
- Hagen, U. (2013). Telephone interview with the expert at Arctic Bulk As. regarding the NSR transit shipping cost.
- Harsem , Ø., Eide , A., & Heen , K. (2011). Factors influencing future oil and gas prospects in the Arctic. *Energy Policy*, 39(12), 8037-8045. <http://www.sciencedirect.com/science/article/pii/S0301421511007476>  
doi:<http://dx.doi.org/10.1016/j.enpol.2011.09.058>
- Hine, L. (2012). Ob River carves passage through NSR, *TradeWinds*. Retrieved from <http://www.tradewindsnews.com/weekly/286920/ob-river-carves-passage-through-nsr> > (Read 12.10.2013)
- Ho, J. (2010). The implications of Arctic sea ice decline on shipping. *Marine Policy*, 34(3), 713-715. doi: <http://dx.doi.org/10.1016/j.marpol.2009.10.009>

- IMO. (2009). *GUIDELINES FOR VOLUNTARY USE OF THE SHIP ENERGY EFFICIENCY OPERATIONAL INDICATOR (EEOI)*. (MEPC.1/Circ.684). London: Retrieved from [http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Technical%20and%20Operational%20Measures/MEPC.1\\_Circ.684\\_Guidelines%20for%20Voluntary%20use%20of%20EEOI.pdf](http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Technical%20and%20Operational%20Measures/MEPC.1_Circ.684_Guidelines%20for%20Voluntary%20use%20of%20EEOI.pdf) >(Accessed 28.09.2013).
- Kumar, S., Kwon, H.-T., Choi, K.-H., Lim, W., Cho, J. H., Tak, K., & Moon, I. (2011). LNG: An eco-friendly cryogenic fuel for sustainable development. *Applied Energy*, 88(12), 4264-4273. doi: <http://dx.doi.org/10.1016/j.apenergy.2011.06.035>
- Lauritzen, T. (2013). Telephone interview with the CEO of Dynagas Ltd. regarding the first LNG transit voyage via NSR of the vessel "Ob River".
- Liu, M., & Kronbak, J. (2010). The potential economic viability of using the Northern Sea Route (NSR) as an alternative route between Asia and Europe. *Journal of Transport Geography*, 18(3), 434-444. doi: <http://dx.doi.org/10.1016/j.jtrangeo.2009.08.004>
- MAN. (2013). LNG Carrier Power: Total Fuel Flexibility & Maintainability with 51/60DF Electric Propulsion. Augsburg, Germany.
- Mulherin, N. D. (1996). The Northern Sea Route; Its Development and Evolving State of Operations in the 1990s (pp. 85). Alaska.
- Nilsen, T. (2012, 06. November.). Hammerfest LNG set sails for Japan via Arctic route., *Barents Observer*. Retrieved from <http://barentsobserver.com/en/arctic/hammerfest-lng-set-sails-japan-arctic-route-06-11> >(Accessed 13.06.2013)
- Norheim, H. M. (Producer). (2010). Strategies for oil and gas development in the Arctic. Retrieved from <http://www.statoil.com/en/OurOperations/FarNorth/Presentations/Downloads/nordisk%20ministraad%20arctic%20-%20Changing%20Realities%20speech.pdf> (Accessed 03.05.2013)
- Offshore, T. (2013). Snøhvit Gas Field, Norway. from <http://www.offshore-technology.com/projects/snohvit-field/>
- Olsen, R. (2013). email and telephone interviews with the maintenance manager for dual fuel engines at Knutsen OAS shipping regarding the fuel consumption of LNG vessels.
- Peters, G. P., Nilssen, T. B., Lindholt, L., Eide, M. S., Glomsrød, S., Eide, L. I., & Fuglestad, J. S. (2011). Future emissions from shipping and petroleum activities in the Arctic. 5305–5320. doi: 10.5194/acp-11-5305-2011
- Platou. (2013). Platou LNG update.
- Ragner, C. L. (2000). Northern Sea Route Cargo Flows and Infrastructure – Present State and Future Potential (pp. 124). Lysaker, Norway. .
- Rodrigue, J. P., Comtois, C., & Slack, B. (2009). *The geography of transport systems* (2nd ed.). London: Routledge.
- Rokstad, E. (2013). Email and Telephone interviews with the expert for Newbuilding and LNG group at RS Platou regarding the charter rates & fuel consumption for LNG vessels.
- SCA. (2013). The Suez Canal toll calculator. from <http://www.suezcanal.gov.eg/calc.aspx> >(Accessed 7.11.2013)
- Schøyen, H., & Bråthen, S. (2010, 11-15 July). *Bulk Shipping via the Northern Sea Route versus via the Suez Canal: Who will gain from a shorter transport route?* Paper presented at the 12th World Conference on Transport Research, Lisbon, Portugal.
- Schøyen, H., & Bråthen, S. (2011). The Northern Sea Route versus the Suez Canal: cases from bulk shipping. *Journal of Transport Geography*, 19(4), 977-983. doi: <http://dx.doi.org/10.1016/j.jtrangeo.2011.03.003>
- ShipSpotting. (2013). OB River. from <http://www.shipspotting.com/gallery/photo.php?lid=1683685> >(Accessed 28.09.2013)

- Skuld. (2013). Telephone interview with Inna Van Spriël an expert at Skuld insurance company regarding the insurance aspects for the NSR transits.
- Staalesen, A. (2013, 04.October). Norwegian LNG to Japan via Arctic route, *Barents Observer*. Retrieved from <http://barentsobserver.com/en/arctic/2013/10/norwegian-lng-japan-arctic-route-04-10> >(Accessed 06.11.2013)
- Stopford, M. (2009). *Maritime economics* (3rd ed.). London: Routledge.
- TimeraEnergy. (2013). Getting to grips with LNG shipping costs. Retrieved from <http://www.timera-energy.com/continental-gas/getting-to-grips-with-lng-shipping-costs/> >(Accessed 14.11.2013)
- Tustin, R. (Producer). (n.d). Future Arctic LNG Ships; Recent developments in LNG and ice-class tanker design and the potential application to future Arctic LNG ships. Retrieved from <http://www.thedigitalship.com/powerpoints/norship05/Ing/Rob%20Tustin,%20LR,%20LNG%20Arctic%20shipping.pdf> (Accessed 12.10.2013)
- Vukmanovic, O., & Koranyi, B. (2013). Russia Arctic Natural Gas Shipping Route to Asia 10 Years Away, *Insurance Journal*. Retrieved from <http://www.insurancejournal.com/news/international/2013/01/28/279017.htm> (Accessed 19.05.2013)
- Wainwright, D. (2012). Ob River reaches Japan, *TradeWinds*. Retrieved from <http://www.tradewindsnews.com/tankers/288201/ob-river-reaches-japan> >(Accessed 12.10.2013)
- Zeus. (2006). LNG IMPORT TERMINAL PROFILE: Tobata LNG Terminal, Kitakyushu City, Kyushu Island, Japan. from [http://member.zeusintel.com/ZLNGR/show\\_image.aspx?id=2425](http://member.zeusintel.com/ZLNGR/show_image.aspx?id=2425) >(Accessed 06.09.2013)
- Østreng, W. (2013). Personal interview with Østreng who served as the head of International Northern Sea Route Program (INSROP) and is the author of the book *Shipping in Arctic Waters*.
- Østreng, W., Eger, K. M., Fløistad, B., Jørgensen-Dahl, A., Lothe, L., Mejlænder-Larsen, M., & Wergeland, T. (2013). *Shipping in Arctic waters: a comparison of the Northeast, Northwest and trans polar passages*. Berlin: Springer.

## Appendices

### **Appendix A**

Interview Guide for Interviewees :

## **Information Sheet for the Participant**

### **Introduction**

My name is Zeeshan Raza and I am writing thesis as a part of my master degree in Maritime Management at Vestfold University College. I have got your name from the book Shipping in Arctic Waters.

### **Research Description**

My thesis is titled as, *'The conquest of the Arctic; A comparative study of the Northern Sea Route in commercial and environmental perspective with focus on LNG shipment.*

The Northern Sea Route is a shipping lane along the Russian coast that connects the Atlantic Ocean to the Pacific Ocean.

The research uses a case study to assess the economic and environmental potential of NSR for the LNG transportation. The cost incurred on a single voyage taking the LNG cargo from Hammerfest Norway to the port of Tobata Japan through the NSR will be compared with the cost spent on the trip through the Suez Canal using the same loading and discharging ports. Also, the CO2 emissions from both alternate passages will also be compared to determine the sustainability factor.

### **Recording of Interview:**

In order to facilitate my note-taking, I would like to audio tape our conversations if you allow. For your information, this recording would only be used by the researcher, which will be eventually destroyed after it is transcribed.

## **Researcher's Responsibilities**

Keeping the ethical aspect in mind, I assure that all the information you purvey, will not be used for any other purpose except this research work. Furthermore, I do not intend to cause any harm to you with my work. I will make sure the confidentiality of the information and your name would not be directly related with any piece of information in the project unless you allow. Some other words such as your name initials, participant, expert etc. can be used in this case. All the notes and audio recordings related to interview will be kept at a secure place.

## **Participant's Role**

Your participation is voluntary and you can leave the interview if you feel uncomfortable any time during the interview. You have no any liability to compensate for that.

## **Feedback**

This thesis will add knowledge and information to the existing literature about the Northern Sea Route, and will be available to the public through the internet and at the library of Vestfold University College. If you want to obtain the findings of this research, you can get a copy of that by email.

## **Enquiries**

If you have any further query, about the research you can contact to the researcher and his supervisor on the following addresses

## **1. Supervisor**

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**Thanks for your cooperation.**

## Appendix B

The consent form used to obtain the interviewees permission

### Consent Form

**Thesis Title:**

*The conquest of the Arctic; A comparative study of the Northern Sea Route in commercial and environmental perspective, with focus on LNG shipment*

**Name of the Researcher:**

Zeeshan Raza

Please mark the relevant box and sign this form for researcher:

I agree to participate in the above mentioned research study. Yes  No

I understand the information about my participation provided by the researcher. Yes  No

I agree to be interviewed by the researcher. Yes  No

I give permission to record the interview. Yes  No

I agree that I will be available for any further interview if required. Yes  No

I am aware that my participation is voluntary and I can withdraw any time. Yes  No

I understand that my response will be treated confidentially. Yes  No

I know that I can contact the researcher if I have any query. I have his contact detail Yes  No

Participant's name.....

Participant's signature.....

Date.....

Please mark this box if you want to get a copy of the research findings and write your email address below.

Email \_\_\_\_\_



## Appendix C

Interview guide for Willy Ostreng:

### Interview Guide

**Interviewee:** Willy Østreng

#### List of Interview questions

**1. What would you say about the potential of the Northern Sea route as an alternate to the Suez Canal, for the LNG shipping?**

“That’s is a big question, but in the light of accelerating sea ice melting there is no doubt that between northern European , northern Asia and northern American countries the northern sea route or the north east passage has a huge potential because its shortcut between the most economically developed parts of the world. So in that respect, if the sea ice is removed by global warming and it is and this is accelerating and if the sea ice that is left is weekend then of course the potential of the suit is enormous. If you go London to Yokohama in japan you save 43 % of the trade distance in comparison with going through the Suez Canal that is 6600nm through the NSR and 11400nm through the Suez Canal. In addition, it goes around same, when you have set a saving in distance it can be transformed in to savings in sailing days and we know that there are multiple examples that 15 up to 18 days can be saved by using the northern sea route instead of the Suez Canal. So in general the very fact this is the shortcut geographically speaking and the fact that the ice both retreating throughout the north pole and the marginal seas are getting ice free and the remaining ice getting weaker, then of course you can use the passage with existing shipping technology. What you will have to do is all the investments to build up a fleet that can cope with ice-infested waters, because even if it is free there will always be icebergs and drifting in the sailing lanes of the ship. Consequently, you will need to have ice-strengthened hull on the freighters and you would need to have icebreakers assistance.

When it comes to LNG of course there is need for LNG in multiple Asian countries, Japan the biggest LNG consumer in the world, China, South Korea there needs are really important in this respect. They have all the experience that going through the traditional

sea routes in southern waters means that they are subjective to piracy, political conflicts in the Suez Canal, in the Panama Canal. Consequently, in order to really have secure deliveries of LNG which then support the idea of going north which is the only place with no piracy and I would argue that where there are no political risks of deliveries being stopped. So as seen from a broader perspective, mean in political and criminal perspective the northern sea route or the Northeast Passage. Because there is difference between NSR and north east passage northern sea route extends from Novaya Zemlya to the Bering Strait whereas the Northeast Passage also includes the Barents Sea, which makes the north east passage a two state passage. We usually think that Northeast Passage is Russian route, to a large extent it is, but little Norway also has to say in this respect. I would say in general that this route has a huge potential to compensate for some of the problems such as political problems we face in southern latitudes. In the post-world war periods Suez canal was closed for several months twice and forcing international shipping to go around Africa which adds extremely to the costs of energy and of course the poor countries, the developing countries are suffering the most in that respect. So again going north has a huge potential provided that ice melting will continue, so that ice is getting weaker and ice is disappearing. So the NSR is a kind of alternative to compensate for political problems in the Middle East, for political problems outside of Somalia. Political problems in the South China Sea you will avoid all these problems by using the NSR. There is huge momentum or motto for those who are in the need of LNG to develop a shipping fleet that can operate in ice-infested waters. When I say ice infested waters it's because the ocean will freeze out in winter but of course then ice is weak and its thinner and it can be combated by the existing ice breaking technology, so even if you have ice this ocean has a huge potential given the melting''

## **2.What sorts of opportunities are emerged because of ice melt in the arctic, for the trans-arctic shipment of LNG cargo along the NSR?**

‘‘Well its shortcut, you avoid political turbulence in southern waters the Suez Canal, south china sea etc. So you compensate for it is a shortcut geographically speaking, politically speaking and the northern sea route has something to offer that the Suez Canal cannot do to the same degree. I can tell you that, when I

headed the International Northern Sea Route Program (INSROP) which started in 1993 and ended in 1999. It was a collaboration between Norway, Russia and Japan I had never been invited to Egyptian embassy in Oslo but when we got press the media paid attention on the research we were doing, all of sudden I got an invitation to the Egyptian embassy for dinner and was given presents for Christmas. I was treated like king and of course, the reason for that was immediately the Egyptian Ambassador saw that this research could be a serious competitor to the Suez Canal. They wanted to know more on that and not only that I was also invite and down to Egypt to make a presentation about the program and the northern sea route for the people working in the Suez canal authorities because they haven't been thinking of the NSR or the north east passage as serious competitor to their own route. All of the sudden they started to do that. And I know that Egyptian embassy is following what's going on up north very closely. so this is just to give you an indication that Egyptian very professional authorities they know that this may be a competitor to the Suez canal. It is understood that the Northern Sea Route or NEP would only take part of the shipping away from the Suez Canal. Because as I said earlier it is within the northern part of the northern hemisphere that you have this shortcut potential the NSR but at the same time the Suez canal is also shortcut for certain ports. The potential of the NSR or NES is that it may in due time take away some of shipping that today goes through the Suez Canal but not all of it. So Egypt would not depend on sea ice, they will still have business but less business that what they have to day. Every year through the Suez Canal almost 20 000 ships pass and this year so far 58 ships passed the NSR. Therefore, we can say that the NSR is still in a trial period but it should be remembered that the German shipping company Beluga sent two ships in 2010 and 2011. They went from South Korea and they should go to Africa somewhere and they earned 3 00 000\$ per ship by going through the NSR instead of going through the Suez Canal that is approximately 600000\$ for two ships going through the Suez Canal. The CEO of the company told us that a new shipping technology would cut the cost even more which will double the earnings per ship to 600000\$ when those ships will put into operation.

There are also shipments that have earned money by going through NSR instead of the Suez Canal. So the potential is there not only the shortcut distance, to save travelling days, to earn money but also to reduce emissions from environmental point of view but that's only between northern ports on the northern hemisphere where the NES offers shorter transport distances that you cut emissions too.

Therefore, that is also one of the opportunities, which are emerged because of ice melting. The parameters you are addressing in your work namely LNG and emissions for certain ports applies''

### **3.How will the ice thaw in the arctic affect the development of hydrocarbons in the region?**

''As we have seen until recently the ice thaw has made multiple states interested in the developments of hydro carbons and in the arctic and that also goes for countries that have no arctic history at all such as china, south Korea, India and Singapore. We can see that big and small countries European, American Asian even tropic countries have expressed interest in this route. When talking about the Singapore which is a tiny little country it nevertheless being a part of tropic areas it's interesting to see that even they have a focus on NSR and that's of course due to the fact that Singapore is a big international shipping hub and to know what's going on in different parts of the world. China has now two contracts with Russia on hydrocarbons both in the Barents Sea and in the Pechora Sea and Tymir so even the western part of the arctic. Seen from Chinese perspective china are interested in the hydrocarbon potential of the arctic. 84% is supposed to be located on the continental shelf within 200 nm economic zone and since the continental shelf in the arctic ocean is a very shallow one and its more easily recoverable if the ice disappears because its shallow waters. The problem for Russia and china in this respect is they have no advanced offshore technology and experience what so ever. So they will to the large extent be dependent on small countries like Norway to extract the oil and gas that is in the shelf. It's also interesting to see that how for instance china then again are now cultivating politically and economically their relationship with Ice Land. The reason for that if you look at location of Iceland in the midst of the Norwegian Sea. China looks at ice land as a future hub of arctic shipping, going through the NSR and also the Icelandic authorities and government do the same, they regard

themselves as being a future hub in this respect and they have already plans to make themselves into a hub. Because Iceland is located in the North Atlantic and they can from their geographical position serve the European continent and they can serve the east coast of United States and for this reason china's one of the biggest embassies is in Reykjavik. This is the policy of the Beijing to build up such a relationship to form an arctic shipping hub. The Icelandic president Olav he has been multiple times to china discussing these kinds of things. Along with this, you see that Chinese governmental representatives also shipping companies they are cultivating their relationships with Canada. Until we handed out the noble peace prize to this Chinese dissident also Norway and reason of course is that these countries are small countries and to be on a good footings with these countries will give them a kind of stepping stone in to the arctic. In addition, it is interesting to see that Norway and Iceland were very favorable for china to become a permanent observer of the arctic council. Therefore, the ice thaw is essential in this respect because there was no movement of this kind when you had the heavy ice in the Arctic Ocean because at that time the Arctic Ocean was a marginal sea at the outskirts of the globe. No one had an interest in it apart from those countries who bordered on the Arctic Ocean that is five countries, Russia was among those countries and Russia was the only country that tried to develop the northern sea route and that started from October revolution in 1918. Apart from that this ocean was out of the beaten track of the international politics, international economy .but now ice thaw opens up a whole new picture both for shipping and for mining and for producing of energy. It should be remembered in this respect that not only the oil and gas and LNG but also parts of this route are extremely rich in strategic minerals of various kinds. Therefore, it is not only the oil and gas but it is also many of the other commodities that are needed in the southern latitudes. So the thaw is single most significant factors in this respect and it is important that the cold war is over and that there is kind of collaboration between all the 8 arctic states. The ice thaw and the change of politics are two main ingredients in this''

**4. How would you comment about the discovery of shale gas in United States and its possible impact on the use of NSR, and how do you see the future of Norwegian gas exports from Snohvit gas terminal, in this context?**

‘Let’s take US first well United states is in the process of getting self-sufficient with gas and this something absolutely brand new one of the biggest consumer of LNG and gas is going to become self-sufficient. That of course will alter the geopolitics of energy in the world and in the light of above answer US in next five years’ time or so will not be that interested as seen a receiving country of oil and gas through the NSR and through the Arctic because it’s getting self-sufficient, not even the ice land will be the hub in that particular respect for the east coast of the US because its self-sufficient but in the other end we may foresee the US to become a net exporter of shale gas for instance to the Asian countries then of course that export is going through the east coast then you will have gas exports from the east coast of united states and even Canada through the NSR towards Asia so we may foresee that the possibility that the NSR which is being considered until very recently as a supply route to the east coast of US may be a supply route from the east coast of US to the Asia so depending again on the politics because china is becoming the biggest economy in the world very soon etc. and there may be political reasons why these will not develop but this is a part of revolution of shale gas that is so hard to know what the new picture will be, but this may be one component of it provided that global politics will see that something beneficial for the US. When it comes to the Snohvit, it cannot no longer sell its gas to the US arctic gas is no longer interested in US as it used to be and Norway will have to try to find new customers in continental Europe which I think they will use the Northern maritime corridor which extends from the white sea to the continental Europe. And we saw it’s established in 2002 as a kind of supplement in ice free waters to the NSR. So now you have established two legs of a continuous route from continental Europe to up north to the Barents Sea and the white sea which continues along the Siberian coast to the pacific. You don’t have a northern pacific corridor, in the pacific. Then you will have a hemispheric transportation route that encircles a whole of Eurasian continents, two continents with shipping routes is a something brand new in this respect. So I see that US may use the NSR in the future for selling its shale gas to Asian countries through the NSR and the Norwegian gas, Russian

oil from the Barents sea and Yamal the white sea the Pechora sea etc will not go to the US because it is much more costly than the Shale gas but at the same time you have a strengthened focus of the global warming, the IPCC now in their last report claim that the global warming is manmade. Of course shale gas production is not very environmentally clean production. So we may even see a growing movement internationally to stop the shale gas production if they succeeded, as we have already seen that some European countries have ban on the shale gas production. There are other countries that do have shale gas also for instance china but they lack the technology to produce it. But we are now to a certain extent caught in the middle of two globally very important , on one hand the production of shale gas which is very polluting and on the other hand a need to stop the global warming. That s part of the revolution of shale gas that it may cause political movements to stop it. At the same time seen from the US point of view this is a high priority in national interest in national interest to be self-sufficient with gas because it has long history of being vulnerable to the turmoil of the middle east which has been the main supplier of oil and gas to the US and now when the opportunity to be self-sufficient they are not likely to reverse that and be dependent again for the deliveries of oil and gas from the other parts of the world. I foresee kind of political clashes between the production of polluting oil and gas and the need to stop the manmade global warming. It should be said that the shale gas evolution is beginning and it's hard to say about all the ramifications will be apart from that fact it will produce changes in international economy, international security.it will and may affect the arctic and the northern sea route and I will point out the NSR use as delivery route to the US that will not happen probably but it may be used as delivery route from the US to the Asia at least to japan, South Korea and Taiwan which are allies to the US. But politics will all the time be a part of equation. Europe using American extra coal....European countries are also with the fact that they will also have to cope with the global warming so although gas pollutes but its lesser polluter than coal and has for instance for Norway been a policy for long to substitute the coal with Norwegian gas and this has been the policy of since 1990. At the same time politics coming into the picture Norway is also producing the coal in Svalbard archipelago despite the fact we selling to Denmark we both have coal and gas and we try to sell it all because it gives income but if you could take away coal and use the gas .but

in the long run you will have to produce and develop alternative energy which they are doing for instance in Germany but the long term production is that the consumption of oil and gas globally will increase more than 60% in the coming 30 years which implies that although you have a long term goal to develop alternative energy we still depend totally on hydrocarbons so there are dilemmas here throughout and they relate to politics. It is not the question of technology and economy, but it has to do with the politics and when it comes to democracies and governments will not be reelected if they took away the standards of living of their populations simply to meet environmental goals that will really hurt the wellbeing of their populations. Oil and gas will still be the fuel of the future in the short and medium term''

**5. The first LNG carrier navigated along the NSR last year Hammerfest Norway towards Japan, how do you feel about this development?**

''Well, I think this development was expected simply because we are producing LNG in the Barents sea and we are looking for customers, and you have customers in Asia, in Europe and you sell where you can sell it and the fact that ice melt is accelerating is possible to navigate these waters without dramatic risks. Russia is important in this respect because Russia has defined its arctic waters as Russian arctic zone and this zone is to be of ultimate importance for the social economic development of Russia as such which implies that whatever takes part of economic activity in the Russian continental shelf etc and in the waters of the territory implies that Russia will develop its resources as fast as can in order to sustain its present livelihood because they are so dependent on selling and production of oil and gas that if it goes down it will hurt Russia tremendously so they will be looking for more and more sources to be developed and they are already transporting from Tymir peninsula towards Murmansk already on a year round basis. They have a fleet of 6 ice strengthened oil tankers that's going from Tymir Dudinka towards Murmansk delivering its oil. So we can see it's already in use and the fact that this stretch which is called the Kara sea route this is part of NSR and NES and it's used on a year round basis then it's not surprising that when the ice conditions allow then they would also go eastward towards the Bering strait and to the customers in the Pacific. So this is just the beginning of the trend that will significantly grow in the coming



years. The fact that Russia claimed the NSR to be an internal transportation route under full and unlimited Russian sovereignty give them all the means they need to keep this kind of traffic in the years to come it may cause conflict because US dispute this claim on the part of Russia but still this is the state of affairs as it is today. The first container ship went from china. so we will see the first shipments of different cargoes in the years to come. So next year we can expect a new first’’

### **5.What are the political and legal challenges for the shipping through the NSR?**

‘‘The legal challenge is here that Russia claims its full and unlimited Russian sovereignty. If it is in internal waters and internal waters the coastal state do have a full and unrestricted sovereignty and that is in accordance with the international law but when it comes to the NSR Russia and Soviet union they included all the archipelagoes along the route new Siberian islands Novaya zemlya etc. as being part of internal waters and that’s highly controversial and US claim this route an international strait that means a strait that international shipping can use by going through the route continuously without e stopping from the one part of the high to the other part of the high sea. That is called transit passage so here the two countries they clash. But at the same time the use of NSR for international shipping has been so modest, that this conflict has not come to the front between them in their relationship so it has been a kind of dormant has been there in principle and it has not been activated if you ignore the kind of incident you had in 1980 but that was a test on the part of US. The interesting thing here is that US has similar clash with Canada over the jurisdiction of NWP. Canada also claimed the NWP to be a part of internal waters of Canada and consequently no one can go through without the explicit agreement of the coastal state of the Canada where as the US says this is an international strait where the transit passage applies. Consequently we can use it this is also quite dormant. But the difference between two clashes is that where as the NWP will not probably be a passage for international shipping whereas the NEP will. Because ice conditions are much better there and there are also other problems connected with the NWP. So the conflict is more likely to flare up in case of NEP as compared to NWP it is more dormant in North America than it is Eurasia. When you take steps from the initial

stage of arctic shipping as we are in now and the volume of shipping along the NSR increases and becomes notable then the is may be. On the other hand it goes same that Russia depend on ships going through and this arctic area is being developed for economic purposes which the NSR is an integral part so it this conflict is resolved and negotiations or if the parties agree to disagree without giving in on their principal stand points is hard to say but there is a potential of conflict in this respect''

**6.What kind of ships and cargo will most likely be competitive on the route, and what are the risks involved?**

Well, when it comes to the cargo we are talking about oil and gas LNG, as a matter of fact container shipping and it will be competitive between those ports in the northern part in the northern hemisphere that can use the NSR as a shortcut .so in principal I don't think that there are any restrictions as to what kind of ships and cargo that will be competitive and that may negotiate NSR if you compare it with Suez canal. The same kind of ships will use the NSR as that use the Suez Canal but there is of course limitations and one limitation is that the coastal part of NSR goes over a fairly shallow continental shelf which will affect the size and draft of ships. There are nearly 58 different straits along the NSR and some of these straits are just 8 meters deep which means that draft of the ships must be small. For example the biggest Russian ice breaker has the draft of 8 meters and basically they are able to operate in most parts of the NSR. So in general the draft of 12 meters is acceptable for the route that is for the coastal area because ice melt is moving northwards then the ships are allowed to sail in the more northern coast then through the straits and then in the central arctic ocean there is thousands of meters of depth which means there are no restrictions what so ever. Or the north of archipelagoes you may have ordinary drafts on the ships but along the coastal parts draft more than 12 meters are not advisable I think but at the same time in 2010 an experimental voyage was conducted where a Russian ship of 116000 dwt went through it was carefully planned to do that but it tells you it is possible to go with bigger ships and also with today's 'technology it is possible to build huge tankers with draft that comply the limits of 12 meters so in the future there is severe restrictions on the draft due to the

fact that shelf is fairly shallow one. But in the meanwhile there is a problem of extra cost of making ships ice strengthened with double hulls. These ships are more costly after the Exxon Valdez accident in Alaska US legislation was that they do not accept ships to call at that do not have double hulls which imply that double hull is already a part of blue ocean transportation fleet. Of course in see ice you will have to strengthen it more depending on if you want to sail in the ice infested waters all through the year or just in summer some parts of the year. Of course ships constructed for arctic waters need special constructions special designs and they are more costly. The question is are they too costly to be competitive with the suez canal and it is described earlier that Beluga shipping earned money on that so I don't think that it is too costly. But there will be some extra investments and apart from this the risks involved in these waters has to do with the environment. It's a very bad combination if you have an oil tanker running a ground and incident of oil spill combination of oil spill and ice is really catastrophic because if you get oil on the top of ice then you reduce the ability of the sea ice to reflect sunlight and the warmth of sun light and then you have the extra absorbance of the sun which ultimately will accelerate the ice melting and it's also extremely hard to recover ice from snow. That may also ruin the life of inhabitants of the arctic mammals polar bears etc. seals and whales can get oil in their nostrils .but this is the fact when you drive on difficult roads like Trollstigen in Norway you will seldom have an accident , the accidents mostly occur on the best and comfortable roads or motorways. Navigating in arctic waters implies that you take extra care while sailing. There hasn't been reported any accidents along the NSR despite the fact that ships have been negotiating this route ever since the October revolution of 1918 it may be the extra caution you pursue you may reduce the likelihood of the accidents''

### **7. Who will mainly get benefit from the shorter route of NSR?**

Those ports in the northern part of northern hemisphere that can benefit from shorter trade distances will benefit from it that is a geographical kind of reasoning. And of course there will be ship owners that will transform their fleet into operating in arctic waters and if they do they will get a competitive edge in relation to those who use traditional route

and the international shipping industry is very competitive and if they can benefit from reducing the freight distance 15 to 20 days then they will do it Tschudi beluga Russian and Chinese shipping companies are using this simply because they make money on that and those who are reluctant to use that will gradually lose their market. Because they will use longer distances, ultimately you will have two groups of shipping companies one using the northern routes and the other using the southern routes that will not benefit from the sailing through the north. The first mover advantage can be the main driving force behind using the NSR. It's interesting to see that Norwegian ship owners association looked at the NEP and transpolar passage in their strategic plan not the NWP and that's interesting.

#### **8. What could be the expected impact of NSR on the international trade in general and on Norway in particular?**

“When it comes to international trade, NSR will be complementary to the Suez Canal both routes will be used for different ports. When it comes to Norway it's interesting because Norway will benefit enormously from the NES or NSR simply because the northern maritime corridor from the white sea to the European continent it's kind of addition and if you look at the addition Norway can for its northern parts be a hub for both repair of ships going through the NSR, for supplies for shipping through the NSR and here we can say that NEP is a two state passage Norway and Russia and Norway is the soft valley of the NEP because we have a certain control of ice free parts of Barents sea so Norway can benefit from this development by kind of being kind of a service nation and of course also as being a big shipping nation some ship owners may convert their fleets to run in ice infested waters then benefit from the shortcut aspect of the NSR. At the same time Norway will suffer from this because increase shipping brings risks along it and Norway will expose to the risk of all kind of pollutions. Norway a long and slim country on the map of the world may both benefit and suffer at the same time”

Yokohama incident in Japan and its impact on NSR.

“We can foresee both US and Japan shipping will go to Japan and Japan is an ally of US. The Yokohama incident may increase the internal demand of energy and US may be the one supplier for that. Norway and Russia may also the eastward trade of the LNG will increase in the future not only due to Yokohama but also to the increasing needs of China in its process of increasing growth so Yokohama will be one aspect will be one element in this respect. And of course Japan being a largest consumer of LNG in the world will now probably rely less and less on nuclear energy and more and more LNG but that’s is an aspect in this respect”

**Other issues:**

“Military of course is a challenge up in the high north. I would assume that naval vessels are there in the north for some summer months and they will have to use the aircrafts or other means suited for polar conditions to monitor and survey their interest in the Arctic but of course you have nuclear submarines in the Arctic sea bed of the Arctic ocean but that’s a different matter. But there has been a tendency to build up a military capability to in support of economic activity that’s relate to the NSR and to the production side of NSR but again thin hulls in contact of ice is not a good combination and it does not comply the intention of polar code which will give international norms for ice strengthened vessels”

## Appendix D

### Interview guide

#### Henrik Falck

#### List of interview questions

- 1. How do you see the scope of Northern Sea Route as an alternate to the Suez Canal, particularly for LNG transportation?**

“The Northern Sea Route can open for new LNG projects in the far North, previously it was like finding a gold mine on the moon it did not help because the transportation will kill everything but today the transportation can be very competitive with alternative sources of supply. The distance from Mostar, Bergen to Yokohama is same as the distance from Arabian Gulf to Yokohama. Of course when you go from Arabian Gulf to Japan you are not crossing any canal, you don't pay any, and you need not to have any ice class vessel etc. Going through the NSR from Melkøya to Tobatta is exactly fifty percent quicker than sailing through the Suez Canal. It opens up a completely new market but what is particular for the LNG trade is that the investments are so huge that nobody starts an LNG plant unless they have the long term contracts and Melkøya was established before the NSR was finished. So everything is sold out but of course they have already done two or three trips through this passage and they are saving 8 million dollars on one trip. In Sabeta, where the Russian company Novatek plans to establish an LNG plant for them the advantage is more better because they are five days close to the Far East market. It will only be of relevance for those who are contemplating to produce LNG up north, for the LNG coming out from the US in future it has absolutely no relevance. I think it's a game primarily for Russia. I often say that the freight will no longer kill the deal because of the northern sea route. Previously if you have LNG up north you were too far away from the consumption market but now you are very close to the market. So that's why investing a huge amount in LNG plant of Yamal, with the 20 percent share of Chinese National Oil company (CNOC) at the Sabeta port.

**2. In your opinion, what is the main driving force behind using the NSR for transarctic shipment of LNG between Europe and Fareast Asia?**

“Of course the distance and the fact as of today the Fareast market is paying premium on this particular product. If that will maintain in the future, as I can remember they are paying 15 per million btu in Japan and on the EU continent its about 10 per million btu. And in USA you have around 7. In my opinion such an imbalance in the market cannot be sustained because now everybody wants to sell to Japan. The price of the product is also a determining factor for the prospective use of NSR. For example previously we were getting 20 percent more on the iron ore product from the Chinese market as compared to the EU continent and of course 50 percent shorter route to the market paying 20 percent more it becomes extremely interesting. So summing up we can say that the ice reduction, technological developments, positive interest from Russia and most significantly the product price are the elements that would have a positive impact on the Northern Sea Route”

**3. How would you compare the average speed of an ordinary and an ice classed LNG carrier?**

“Hoegh LNG can assist in this regard”

**4. What is the fuel consumption per nautical mile of an ice classed and ordinary LNG carrier?**

“Hoegh LNG can assist in this regard”

**5. How many days it takes for an LNG carrier, starting its voyage from Hammerfest, Norway to reach the northern port of Tobata, Japan, via NSR and Suez Canal?**

“According to my calculations the distance from Hammerfest-Tobata is (6132nm 19.66 days via NSR) and (12146 nm 38.93 days via Suez Canal)”

**6. How would you comment about the charter type for ice classed LNG vessels and does the charter rate include the operational expenditures such as manning, H&M insurance, P&I insurance, repairs and maintenance, administration and others?**

“Unable to provide as they mainly deal in Bulk”

**7. What is the average charter rate per day for a (L’loyds) 1A ice classed LNG carrier with capacity of 150000 cubic meters?**

“Contact to Ulf Hagen at Arctic Bulk and Hoegh”

**8. What could be the estimated NSR surcharge for a (L’loyds) 1A ice classed LNG vessel carrying 150000 cubic meters of LNG?**

“Contact to Ulf Hagen at Arctic Bulk and Hoegh”

**9. Can you please provide the cost figures for the following components of operational cost of an ordinary and ice classed LNG carrier?**

- Manning
- Hull & Machinery insurance
- Protection & Indemnity insurance
- Repairs & Maintenance
- Administration & others

“ not in a position to provide such data”

**10. What do you think that a change in the NSR surcharge and bunker price for the LNG carriers would have any impact on the profitability and potential use of NSR as an alternate to Suez Canal?**

“Definitely, a reduced rate of the NSR fees would attract the shipping players and the higher bunker price in the future would increase the traffic on Northern Sea Route due to a shorter distance”

**11. Up to what extent the shorter distance along the NSR reduces CO2 emissions from the LNG vessels navigating between Hammerfest and Tobata in comparison to the Suez Canal; can you please provide the figures for that?**

“Hoegh LNG can give you these figures.”

**12. What are the possible benefits or costs connected to ship operations on NSR over Suez and how are these benefits and costs taken in to consideration in the decision making process?**



‘Of course it is a shortcut trade route for imports and exports between Atlantic and Pacific, you make huge savings in terms of fuel costs for example and this can help to gain the competitive advantage’

**13. Please provide the other issues’ impact future LNG vessel transits along the NSR?**

‘If you want to know that how much a vessel owner will earn you need to calculate the TCE

Net freight = Freight (income) – commission to the broker

In the voyage calculation you always calculate from the loading port to the port of discharge.

But if you want to make such a comparison as you are doing now Suez versus NSR you always have to calculate on a return basis, you have to bring the vessel back to compare the apples with apples. If you only take the good paying leg it would give you wrong indication.

For instance almost all the big VLCC tankers are loading in Arabian gulf and then they go the States, but if you only calculate that trip, what the hell this vessel do when it is in the States as it is only one way therefore you must have consider the back haul voyage. And the same is for LNG vessels. So the first thing is to find the distance between A to B based on this distance we know the fuel consumption and the bunker cost, may be you have canal cost and then you have the port charges, on the basis of these figures you conclude the net result. You divide the net result and divide by the number of days this voyage has taken. This is how to calculate the TCE ( Time Charter Equivalent).

Second, if an owner want to know that how much money I made the whole year then you take the TCE for 360 days because 5 days are allocated for dry docking or unplanned stoppage.

The next thing is running cost that includes crewing, insurance, maintenance allocation for dry docking. That figure is normally calculated on per day basis. I know that running a medium sized bulk carrier that will cost 5000 dollars a day, for a VLCC its 10000.

You start with the time charter equivalent and you deduct your running cost because it’s the cost you must have to bear no matter whether the vessel is standing still or moving and the

last element is the capital cost; these are the three costs on which all the shipping people focus on”

“The point is that when you do logistics and transportation it is not only the distance that counts, everybody knows that distance through the NSR is shorter than the Suez canal, but a very important element here is the direction of the cargo. Some directions in the Atlantic normally pay the same as up and down in the Pacific, but going from Atlantic to the Pacific you get twice as much but on the voyage back to the Atlantic you get nothing so the direction in shipping is very important. For example when you hire a Taxi to Airport they smile because they know that they would get the business back, so normally you can negotiate down the rate, but when you are the airport unless there is huge competition it will be a fix price going back. So this is important to consider that the cargo is eastbound or west bound and in particular for the LNG the market is of course is in the Far East because they are paying 50% more than anybody else because of Fukushima incident for example. But all the vessels when they have discharged in Japan they have to go back their loading place, it could be Norway, Russia, US Australia or Qatar, so you always have to do this on a round voyage basis”