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Climate Change and Singapore

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School of Civil and Environmental Engineering
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2011
Climate Change and Singapore

Submitted by
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EXECUTIVE SUMMARY

The Arctic is a region located at the Northern Hemisphere, accounting for about 6 percent of the Earth’s total surface area. The Arctic which was covered in ice caps and glaciers was once impenetrable by humans. At present, ships are able to pass through this region for a period of 3 to 4 weeks. This phenomenon is caused by climate change, resulting from the increasing release of Greenhouse gases into the Earth’s atmosphere which accelerated the melting of Arctic’s ice caps and glaciers.

This led to the opening of the Arctic sea routes and a more accessible Arctic region. Although there are no official routes through the Arctic as ice is constantly changing in pattern, explorers have found three main Arctic passages namely the Northeast Passage also known as the Northern Sea Route (NSR), Northwest Passage (NWP) and the Central Arctic Ocean Route. Commercial shipping is benefitting from the shorter distances of these routes as compared to the traditional Suez Canal Route.

This report focuses only on the NSR as it is the most commercially viable route. The Arctic is most vulnerable to climate change and this report will touch on the possible impacts of global warming and climate change on the Arctic as well as how this would lead to the opening of the various Arctic sea routes. Furthermore, an outlook into the year 2050 will be discussed with issues on the demand and supply of oil and gas. In addition, alternative sources of energy and modes of transportation would be looked into for the future.

Last but not least, propositions on possible business opportunities for the Singapore maritime industry are proposed in view of the opening of the NSR.
ACKNOWLEDGEMENT

I would like to show my appreciation to my Final Year Project Supervisor – Professor Bengt Ramberg for his continuous guidance and support throughout the whole duration of this Final Year Project.

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In addition, I would like to thank my group members – Lim Wei Ling and Lee Kay Li for their constant support and encouragement and for making this project an enjoyable one.
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CHAPTER 1: INTRODUCTION

1.1. Background

Global warming and climate change has taken the front seat in today’s international discussions with various talks on climate change and the reducing of carbon emissions. This international issue would not be solved overnight and it requires the effort and cooperation of the entire world. A significant phenomenon which has caught the attention of the many today is the issue of climate change and the Arctic.

The Arctic is a region located at the Northern Hemisphere with an area of 14 million square kilometres. (Karl, 2009) This accounts for about 6% of the Earth’s surface area which is roughly the size of an African continent. (Philip, 2009)

Eight countries have territory over this area and are often referred to as the Arctic countries. They are namely the United States (Alaska), Russia, Canada, Denmark (Greenland), Norway, Sweden, Finland and Iceland. These eight countries are member states of the Arctic Council which was established in 1996. Out of the eight Arctic countries, five of them are recognized as Arctic coastal states and these countries include the United States (Alaska), Canada, Russia, Norway and Denmark (Greenland). (Ronald, 2010)
The five Arctic coastal states are in the midst of an Arctic territorial claim for submission to the Commission on the Limits of the Continental Shelf. (Ronald, 2010) These claims arose from their wants to seize control of the Arctic’s resources which is said to potentially hold as much as 25% of the world’s remaining undiscovered reserves for oil and gas. (Badari, 2010) According to the US Geological Survey 2008, it is estimated that the amount of undiscovered Arctic oil and gas is worth 90 billion barrels of oil, 4.4 billion barrels of natural gas liquids and 1,670 trillion cubic feet of natural gas. (Donald and Brenda, 2008) Moreover, reports by Russian News Agency, Ria Novosti, states that deposits of coal, nickel, gold, diamond and other minerals were also found under the Arctic Ocean (Ria Novosti, 2010).

The Arctic which was covered in ice caps and glaciers was once impenetrable by humans. However, global warming and climate change have ironically paved the way to the accessibility of these resources. At present, ships are able to pass through this region for a period of about 3 weeks. This phenomenon is a result of the increasing release of greenhouse gases into the Earth’s atmosphere which slows down the process of heat escaping from the Earth’s atmosphere.
Climate models used by the Intergovernmental Panel on Climate Change (IPCC) have predicted a 3 to 4 degree rise in global temperature in the next 50 years and this is bad news to environmentalists as this could accelerate the melting of the Arctic ice caps and glaciers. A decreasing rate of 3 to 5 percent per decade of total ice extent is forecasted. (Joshua, 2009) Thus it is evident that global warming will have a strong impact on oil and gas exploration, and ship transportation along the Arctic sea routes.

Looking ahead into the year 2050, it is evident that there will be significant changes to transport scenarios and energy mix used to fuel the world economy. This is caused by variations in demand and supply of oil and gas as well as rising environmental concerns by regulatory bodies.

The impacts on Singapore should not be overlooked as this could bring about good and bad news to Singapore’s economy. Thus Singapore should be prepared if the impacts were negative and to take advantage of the opportunities presented if otherwise.
The whole report is divided into 3 parts with each student researching on 2 work packages. This research paper encompasses work package 5 – the impacts of global warming on the Arctic and work package 6 – looking ahead into 2050.

Kelly Lee will be providing a deeper understanding of the Arctic Region and Russia namely work packages 1 and 2.

Lim Wei Ling’s research paper will include work packages 3 and 4 which will explain more about shipping carbon emissions and green Arctic technology.

Figure 2: Project Organization Chart
CHAPTER 3: LITERATURE STUDY

3.1. Impacts of Global Warming on the Arctic

Objective

Based on a background study of climate change and global warming, a research to find out the impacts of global warming on the Arctic is studied in terms of the degree of Arctic ice melt and the opening of Arctic trade routes.

3.1.1. Global warming

Global warming is the slow and gradual warming of the Earth’s atmosphere resulting from the increasing release of greenhouse gases. The main sources of greenhouse gas emissions come from industrialization mainly from the burning of fossil fuels for our energy needs. (EIA, 2004) Greenhouses gases comprise of carbon dioxide, methane, nitrous oxide, ozone, water vapour, and fluorinated gases. These greenhouses gases present in the Earth’s lower atmosphere trap solar radiation and act as a warm air-blanket surrounding the Earth. (Larry, 2010)

Greenhouse gases are essential to support life on earth. There will be no life on Earth without these gases as the temperature will be much lower than it is now. However, an excessive amount of greenhouse gases will prevent solar radiation from being reflected back into space. This process is called the Greenhouse Effect. Hence global warming is brought about by a rise in average global temperature.
The primary contributor to global warming is carbon dioxide which accounts for about 76% of the total greenhouse gases. (Nick, 2010) Carbon dioxide concentration in the atmosphere has been on the rise due to human activities and will remain in the atmosphere above natural levels for centuries, despite a reduction in carbon dioxide emissions. (Susan, 2004) Thus it is unwise for the impacts of global warming to be ignored.

These impacts can be categories into the three main groups, mainly weather, nature and people.

Impacts on the Weather (WWF, 2010):

- Increase in temperature
- Changes in rainfall patterns and precipitation
- Rise in frequency of natural disasters
- Diminishing glaciers
- Rise in sea level
- Increase in intensity and frequency of El Nino and La Nina

Impacts on Nature (WWF, 2010):

- Extinction of species
- Threatening of ecosystem
Impacts on People (WWF, 2010):

- Affect water supply and quality
- Changes in agriculture yield
- Destruction of construction
- Higher insurance premiums
- Shift in tourism patterns
- Spread of infectious diseases
- Flooding of low-lying areas

3.1.2. Climate Change

Climate Change is defined as the result of long-term significant changes in weather patterns due to an increase in the Earth’s average global temperature. (The State of Victoria, 2010) According to the NASA’s Goddard Institute for Space Studies, the average global temperature has climbed 0.8°C since 1880s.

![Figure 4: Global Air Temperature](image)

**Source:** Climate Research Unit (2010) Global Temperature Record

Higher global temperature has quickened the rate of evaporation, leading to an increase in air humidity, therefore intensifying the severity of floods and storms associated with El Nino. (Larry, 2010)

In addition, the increase in average global temperature has accelerated the melting of ice caps and glaciers over the past 30 years, resulting in a hike in global sea level since the late 1800s.
There may be other factors which account for the overall rise in global sea level; however, they are tough to measure (Philippe, 2000).

![Figure 5: Sea Level Rise Due to Global Warming](source)

### Figure 5: Sea Level Rise Due to Global Warming

Source: United National Environment Program (2009), Sea Level Rise due to Global Warming

Last century recorded a 10 to 20 centimetres rise in sea level. A projected sea level rise of 10 to 90 centimetres to occur this century due to accelerating melting of sea ice and excessive runoff will add more freshwater to the ocean, thus reducing the level of ocean salinity and density. If this trend were to persist, it would likely cause ocean circulation patterns to change. This will have a strong impact on the regional climate. (Susan, 2004)

Moreover, with a rise in sea level, there is a possibility that low-lying countries will experience flooding. According to The Tyndall Centre for Climate Change Research in Britain (2008), Asia would be the most affected continent due to its vast low-lying coastline being surrounded by the ocean. Billions of people across Brunei, China, Cambodia, Indonesia, Malaysia, Myanmar, North Korea, the Philippines, South Korea, Thailand, Republic of China and Vietnam would be affected. (Michael, 2008)
3.1.3. Degree of Arctic Ice Melt

Although greenhouse gas emissions do not originate from the Arctic, global warming is most intensively experienced and felt there. The global warming effects in the Arctic Circle are an early indication of the environmental and societal changes which will be of significance in the future. (Susan, 2004)

Changes in the characteristics of precipitate have caused an increase in the annual total precipitation by approximately 20%, in the form of rain. This happens mostly in winter and to a lesser extent in the other seasons due to global warming (Susan, 2004). Winter rain which falls onto existing snow caps, causes faster snowmelt and in extreme rainfall cases, flash flooding will occur.

Another climate pattern observed in the Arctic is the rising temperatures in the winter season. Winter temperatures in Alaska and Western Canada have surged as much as 4°C in the past 50 years. According to researchers at the National Snow and Ice Data Centre, the Arctic sea ice melted to its lowest level of 1.65 million square miles in summer 2007 (Paul, 2008) (Science Daily, 2008).

Climate models are often used to project average Arctic and global temperature increases. Results from Figure 6 shows that the temperature increase and year-to-year variability in the Arctic are projected to be much greater in comparison to the world. By 2050, the projected surface air temperature change could escalate by much as 3°C.
Sea ice reflects approximately 85 – 90 percent of the Sun’s heat away from the Earth while ocean water reflects only about 10 percent. Therefore when sea ice melts, 90 percent of the heat would enter the ocean. The melting of this highly reflective Arctic sea ice reveals more ocean surfaces, in turn allowing more solar radiation to be absorbed by the ocean surface and less to be reflected back into the atmosphere, leading to more melting. (Anthony, 2008) The slowing down of ocean circulation brings heat from the tropics to the poles, hence affecting global and regional climate. This self-reinforcing natural phenomenon which amplifies global warming and accelerates the warming trend is known as the Albedo cycle. (Susan 2004) (Paul, 2008)

Dr. Maslowski and Igor V. Polyakov (2007), who are Arctic experts, also added that rising flows of warm waters entering the Arctic Ocean through the Bering Strait between Alaska and Russia, will contribute to warmer waters. With warmer ocean waters, this contributes to greater ice loss, pushing the already thin ice pack over the edge (Science Daily, 2008). Figure 7 shows the decrease in area of ice extent in the Arctic Circle from 6.2 million square kilometres in September 1999 to 5.4 million square kilometres in September 2010. This shows an alarming shrinking rate of 12.9 percent over a span of 11 years.
Research scientist, Walter Meier (2009) emphasized that sea ice thickness is an indicator towards the health of the ice cover. The thinner the Arctic ice cover, the more vulnerable it is to melting in the summer. The thinning of the Arctic ice will disrupt the equilibrium in the Arctic Ocean, depleting the world’s total amount of freshwater and decreasing the salinity of the seawater. (CBC News, 2010)

In 2008, the average thickness of Arctic sea ice fell by 26 centimeters as compared to the last 5 years. (Henry, 2008) Although many scientists placed much focus on Arctic sea ice extent, Arctic ice thickness should also be given an equal amount of attention too. If this rate of melting were to continue, an ice-free Arctic would be seen as early as 2030, and no later than 2060. This would give way to a more accessible Arctic region. (Anthony, 2008)
The dwindling ice caps and glaciers in the Arctic region spell both good and bad news. The good news is accelerating ice melt will give rise to a whole new aspect to Arctic shipping. This continuous reduction is likely to lengthen the navigation season and increase marine access to the Arctic’s natural resources (Susan, 2004).

On the other hand, the bad news is that a reduction in sea ice extent will endanger the habitat of Arctic animals, pushing some species to extinction as well as a northward habitat shift for others. (Susan, 2004) Furthermore, a diminishing Arctic sea ice gives rise to coastal wind build up of strength and speed thereby eroding the coastal region. (Susan, 2004)

The once remote and unguarded lands spark national security and sovereignty issues due to disappearing sea ice and this increases illegal entries. National security around the Arctic has to be tightened to safeguard these lands, direct ship movements, defend against hostile forces and conduct search and rescue activities. (Susan, 2004)

The thawing of permafrost in the Arctic also leads to undesirable consequences. Permafrost refers to the permanent frozen state of the soil surface which remains below freezing point and forms during winter to produce a frozen layer that persists throughout the following summer. (Natural Resources Canada, 2007) The thawing frost ground destabilizes existing infrastructures and this would require frequent replacement and maintenance. Moreover when the ground thaws, bacteria and fungi would breakdown carbon contained in the soil, thus releasing more greenhouse gases into the atmosphere. (Aaron, 2008)
Permafrost degradation would also impact the natural ecosystem with the deliquescing of ground surface, subsiding levels of lakes and forming of wetlands. According to Karl Magnus (2009), as much as half of the permafrost present in the Arctic Ocean would thaw by 2050.

### 3.1.4. Opening of Arctic Sea Routes

The change in global climate patterns, hinting at a warming of global temperatures, is offering new opportunities for international transportation. (Rodrigue, 2011) With the thawing of the ice notably around the Arctic region, this brings about a whole new aspect to commercial shipping. (Nathan, 2009) It is said that these Arctic routes would shave off a significant distance from the Far East to Europe trade route via the Suez Canal. Furthermore, these routes could provide a means to transport natural resources, such as oil and gas extracted from the Arctic.

Presently, there are three main Arctic routes namely the Northern Sea Route (NSR), Northwest Passage (NWP) and the Central Arctic Ocean Route.

**Figure 9: Arctic Marine Geography**

The NSR, also known as the Northeast Passage (NEP), is a shipping route between the Pacific Ocean and the Atlantic Ocean. The NSR crosses the five Arctic Seas: the Barrents Sea, the Kara Sea, the Laptev Sea, the East Siberian Sea and the Chukuchi Sea, measuring a distance of 2100 to 2900 nautical miles (Liu and Jacob, 2007) along Russia’s northern border from Murmansk to Provideniya. (Ronald, 2010) The NSR could be used as an alternative for shipping routes between Northeast Asia (north of Singapore) and Northern Europe. (Ronald, 2010)

The NWP is a passage through the Arctic Ocean, connecting the Atlantic Ocean and Pacific Ocean (Britannica, 2010) bypassing the Canada Arctic Islands (Ronald, 2010). The NWP is a potential trade route between Northeast Asia (North of Shanghai) and the Northeast of North America. However, many consider the NWP to be of a commercially less viable option, as compared to the NSR, as ice is still present at many of the channels along the NWP. (Ronald, 2010)

The Central Arctic Ocean Route also known as the transpolar route is a shipping lane which cut entirely across the North Pole from the Greenland Sea to Chukchi Sea.

Currently, cargo transportation takes place along the NSR during the summer months, from the beginning of July to the end of October. The navigation season is defined as the number of days
per year with less than 50% sea ice cover. (Liu and Jacob, 2007) This is made possible with the use of a highly advanced fleet of icebreakers. However, establishing a viable year-round cargo transportation system is still not possible given the current state of ice formations. (Nathan, Devinder and Elisabeth, 1994)

The Arctic Climate Impact Assessment (ACIA) predicted ice-free summers in the Arctic Ocean in 30 to 50 years time. Figures from the ACIA also indicate that the NSR sailing season will be prolonged from the current 20 – 30 days to about 120 days in 2080. (Ragner, 2008) The primary benefit of using the NSR is the reduction in distance to save time and costs. Table 1 shows the percentage of distance change from using the respective alternative routes with respect to the traditional route (Suez Canal). The distances saved in these shorter routes could provide immense savings from operational and voyage cost, a lower breakeven point and a high profit margin for the ship owner involved.

<table>
<thead>
<tr>
<th>Traditional route distance (nm)</th>
<th>Alternative route</th>
<th>Distance (nm)</th>
<th>% change in distance w.r.t traditional route</th>
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<tr>
<td>Rotterdam</td>
<td>Shanghai</td>
<td>Suez-10525</td>
<td>Polar passage</td>
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<td></td>
<td></td>
<td></td>
<td>NSR</td>
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<td></td>
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<td>NWP</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Cape of Good Hope</td>
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Table 1: Distance Comparison Table

On the other hand, it is important to consider the navigational challenges along the NSR. First and foremost, the ice conditions in the Arctic pose great concerns for navigation. As the first year ice starts to form during the winter season, the unpredictability of these ice conditions will hamper the navigation along this route. Vessels which are not properly equipped with ice-classed characteristics would be severely damaged during their navigation. The Marine Operations Headquarters (MOHQ) was set up by Russia to provide current and forecasted ice conditions during navigation. The MOHQ has authority over the NSR and permission must be granted to vessels before transiting through the NSR. (Liu and Kronbak, 2010)

Another concern along the NSR is the shallow depths along the coastal waters of Russia. This prevents the use of larger vessels as they risk the chance of running aground. This is shown by Figure 11 which displays the depth of the Russia’s coastal waters.
Weather conditions are another factor which affects the navigational condition along the NSR. Arctic nights are long and this could lead to visibility problems. (Badari, 2010) A lack in satellite support along the NSR could lead to communication problems. Moreover, the Global Positioning System (GPS) used in the Arctic – GLONASS, is not compatible with all international ships. GLONASS has to be made compatible with international ships before the NSR can become an international viable commercial route. (Ship and Ocean Foundation, 2001)

3.2. Looking ahead into 2050

Objective

An analysis to find out how trade scenarios, alternative modes of transportation and changes in energy mix that fuel the world economy would differ in the year 2050 will be discussed.

3.2.1. Alternative Sources of Energy

Energy is the lifeline of modern economies. Reliable energy fuels technologies and services for developed countries as for developing countries, expanding reliable and affordable supplies of
energy improves their way of life and supports economic and population growth. (ExxonMobil, 2010)

World energy consumption, driven by economic and population growth in developing countries, is predicted to increase by 49 percent within the next 25 years. Most of this predicted growth is said to occur in China and India. (African Global Media, 2010) Organization for Economic Cooperation and Development (OECD) countries will account for only 13 percent of the increased in energy consumption. (World Nuclear News, 2010)

As of 2007, both China and India together, had accounted for about 20 percent of total world energy consumption. With their strong economic growth, the combined energy consumption of China and India will double by 2035, accounting for 30 percent of world energy consumption (Energy Information Administration, 2010).

Since the early 1990s, China’s demand for oil started to exceed domestic production. China has become the world’s second largest oil consumer after the United States. A study by a Paris based International Energy Agency (IEA) expects that half of global oil demand growth will come from China in five years time. (Michael, 2011)

With China’s economy set to reach US$123 trillion in 2040 (Robert, 2010), supported by an 8.7 percent growth in 2009 despite a global economic slowdown, the expansions of these newly industrialized countries would cause uproar in oil demand (Chris, 2010). India is another emerging nation contributing to soaring oil consumption with a growth rate of 7.4 percent in 2009. (The Wall Street Journal, 2010) Furthermore, with other rising nations like Russia following closely behind, the demand for oil will see a continuous upwards trend.

It was reported by the World Bank Group (2010) that in less than 40 years, the Brazil, Russia, India and China (BRIC) economies could be larger that the Group of Six (G6) economies put together. (Dominic and Roopa, 2006)

The supply of oil, on the other hand, has not been increasing in proportion with the demand for oil. As oil is a global commodity, the price of oil is dependent on world supply and demand. The dramatic increase in oil demand worldwide is causing a surge in oil prices.
Statistics of bunker prices from Bloomberg supports the theory that oil prices is rising. The figure below shows Bunker 380 prices from 4 different countries for an 8 year period. The average bunker prices for each month from each country are tabulated and a chart is plotted.

In 2003, bunker prices were about US$200/MT however in 2010, bunker prices doubled by at least twice that amount reaching as high as US$500/MT. The general trend of oil prices can be seen to be constantly rising although the peak oil price in 2008 has to be ignored as this is pushed up by market forces of demand and supply.

Figure 12: Prices for Bunker 380
Source: Bloomberg

The issue over the supply of oil is a tricky one. A report by the United States Government Accountability Office (2007) estimates that oil production will peak sometime between now and 2040. The timing of the peak is dependent on various uncertain factors that will influence the rate of oil consumption. These uncertain factors encompass the amount of oil remaining in the ground and future oil demand. (GAO, 2007)

Organization Petroleum Exporting Countries (OPEC) controls most of the estimated world oil reserves. However, they are not verified by independent auditors and hence the amount of oil in the ground is highly uncertain. Moreover, many parts of the world have not been fully explored such as the Arctic which is estimated to hold 90 billion barrels of undiscovered oil. The question of technology, cost and environmental challenges faced to ultimately produce the oil is also another factor. This is especially true in the Arctic region as newer and more advanced
technology is required to head oil exploration in that area so as to minimize environmental degradation. (GAO, 2007)

Two major issues affecting the world’s demand for energy mix are climate change and peak oil. Climate change which is a growing concern for many nations today is causing countries to go into a state of conflict as it is a thorny one to solve. Developing countries which have contributed the least to this problem, are suffering the most. These countries are seeking payments to make them less vulnerable to the impacts of climate change since the build-up in greenhouse gases is mainly contributed by developed countries. (Andrew, 2007)

Peak oil which refers to the peak in global oil production is a problem to energy resource depletion. Oil is a non-renewable resource and has powered world economies for over the last one and a half century. Once half of the original oil reserves are used up, oil production is likely to stop growing and will then begin a terminal decline. Hence, peak oil would mean that oil prices will continue to soar exponentially. (Adam, 2011) Oil fields will become uneconomical and no longer viable the day it takes a barrel of oil to extract a barrel of oil.

Energy is always needed to drive economies and to support population growth. With oil prices continuously on the rise, researchers can only look for other alternatives such as natural gas to be substituted for oil as a source of energy.

![Figure 13: Natural Gas Price Diverges From Oil](Source: NYMEX Futures Price (2010))

Natural gas is a non-renewable fossil fuel burned to produce energy. It is one of the safest, cleanest and most useful sources of energy with a relatively low greenhouse gas emission and high energy efficiency. It accounts for 22 percent of the world’s energy mix and demand is
growing especially in OECD countries. (NaturalGas, 2010) It is predicted to be one of the fastest growing electricity generation sources by the EIA (2010). (Richard, 2010)

The nature of natural gas is similar to other commodities with its prices reflecting the ability to meet demand and supply. Increasing natural gas production from rising gas demand, take up longer lead times due to the acquiring of leases, securing required government permits, exploring seismic work, drilling and connecting wells to pipelines. Existing gas wells will also decline naturally at some point. Hence, with increasing demand and rising prices, it takes time to adjust the supplies of natural gas. The relationship between variations in the supply and demand of natural gas is referred to as the “natural gas market cycle”. (NaturalGas, 2010)

The demand for natural gas in Asia Pacific is expected to grow at a compounded rate of 4.9 percent within the next 10 years. This is said to be due to the region’s changing climate policies – energy sources with lower carbon emissions.

In today’s market, Japan, South Korea, Taiwan and Spain account for 70 percent of all LNG imports. However, experts foresee that with emerging markets such as China and India switching to LNG, they will likely take a bigger share of the pie, given their growing economies and increasing urbanization, leading to a higher demand for energy. In addition, market watchers envision one-fifth of China’s total energy needs to be met by natural gas in 15 years time. (Travis, 2010)

Natural gas could be used to replace liquid fuels in transportation. Currently, cars are retrofitted with compressed natural gas (CNG) systems used to fuel their engines. In shipping, there are currently a small number of LNG barges and this is mostly seen in short sea shipping. Studies have shown that burning LNG for a medium sized vessel could reduce carbon dioxide emissions by 23 percent as compared to running on conventional fuels. Moreover, LNG does not emit sulphur or particulate matter, making it an ideal source of energy for vessels transporting around the Emission Control Areas (ECAs). In addition, using LNG also reduces Nitrogen Oxide (NOx) by 92 percent. (Øivind and Jon, 2010)

However, there are many issues that deter the use of LNG as an alternative source of fuel in shipping. LNG requires up to 4 times more physical space for storage onboard a ship as compared to conventional fuels. This is due to the need for cryogenic storage and pipe installation thus resulting in requiring enlarged fuel tanks and tank room. This is undesirable for
deep sea shipping as it could mean a reduction in freight capacity since more space is needed to store LNG and hence a reduction in potential profits. (Øivind and Jon, 2010)

Another factor to be considered is the current supply of LNG networks. Bunkering is particularly important to vessels sailing across the world from one end to another. Vessels stop at specific locations to bunker and the current poor supply network of LNG is an obstacle to shipping. Norway is the only country presently, with an adequate supply network to refuel LNG for vessels. (Øivind and Jon, 2010) It may take decades to build out the supply chain for other countries, changing current oil stations to natural gas stations. (Dave, 2009)

Although this change may take decades to form, it is not impossible. Statistics have shown that the number of vessels running on LNG is on the rise. Det Norske Veritas (DNV) (2010) also commented saying that given the current environmental pressures forcing ship owners to use cleaner burning fuel, LNG will become the dominant fuel source for all merchant ships within the next 40 years. (Alaric, 2011)

After the recent nuclear power crisis in Japan, it is reported that this may lead to a new wave of interest in other unconventional sources such as shale gas which is gaining popularity over the past few years. Shale gas is found in tiny cracks of rocks buried below the Earth’s surface. (Rachel, 2011) Shale gas differs from conventional natural gas in that they form within the organic-rich shale source rock. The low permeability of shale gas prevents it from migrating to more permeable reservoir rocks. On the other hand, when natural gas migrates towards the Earth’s surface from an organic-rich source formation into highly permeable reservoir rocks, conventional gas reservoirs are created. (Geology.com, 2011)

Shale gas production is not economically feasible without horizontal drilling and hydraulic fracturing because the gas would not flow from the formation at high enough rates to justify the cost of drilling. (Geology.com, 2011)
Channel News Asia (2011) reported that shale gas is forecasted to meet 29 percent of US energy demand by 2020. There has also been an increasing interest in harnessing shale gas in other countries like Asia Pacific, South America and the Middle East. (Rachel, 2011) It is publicized by a Navigant Consulting Report (2011) that the United States has 100 years worth of natural gas supplies. However, conservative estimates peg United State recoverable natural gas supplies to be at 1,680 trillion cubic feet, or 88 years worth of supplies. These conservative estimates ignore the potential of unconventional gas production from shale, coal-bed methane and tight sands. (Jasmin, 2008)

Shale gas was once unreachable, but with advanced technology in horizontal drilling and fracture stimulation, this has given access to enormous amounts of natural gas needed to drive the world economies. (Jasmin, 2008)
Renewable energy is another source of energy which should not be left out. Energy resources such as wind and solar energy are examples of renewable energy which are constantly replenished and will never run out. (RenewableEnergyWorld.com, 2011) At present, it accounts for 3 to 4 percent of the global energy mix. This is likely to increase to 7 percent by 2020 and 14 percent by 2030 and this would increase further in 2050. (Rachel, 2011)

The Straits Times (2011) reported that Singapore is charging forward to become a powerhouse in renewable energy. Other countries are also seen following suit in this renewable energy race. 5 percent of Thailand’s current energy demand is met by renewable energy but aims for 20 percent of it to be met by 2020. (Chua, 2011) In Europe, a plan known as the Super Smart Grid could power Europe using renewable energy completely by 2050. (Greenlaunches.com, 2011)
A two year study by the World Wildlife Fund (WWF) was quoted saying that all of the world’s energy needs could be provided cleanly, sustainably, and economically by 2050. Relying on fossil fuels to feed world energy demand would only increase anxieties over energy costs, security and climate change impacts. By adopting a 100 percent renewable energy future, this would bring about an 80 percent reduction in carbon emissions by 2050. (ClickGreen, 2011)

However, for the world to be completely powered by renewable energy is definitely something which would not be seen in the near future. In-depth research has to be done and more sophisticated infrastructure has to be in place to better capture and utilize renewable energy.

Figure 17 below shows the percentage of change in energy sources between the years 2000 to 2050. It can be seen that global renewable energy is picking up between now till 2050 and that the use of non renewable sources such as oil, coal, and nuclear energy will take a backseat.

![Figure 17: Energy Used by Source between 2000 and 2050](source)

Source: Cook (2011) A Plan for 100 Percent Renewable Energy by 2050

3.2.2. Increasing Trade in the Arctic

With increasing ice melt over at the Arctic region, the NSR could become the new sea highway between Europe and Asia. Ongoing climate changes and retreating of summer ice caps in the Arctic will be seen as a new opportunity for commercial shipping. The distance from Europe to Asia via the NSR is about 40 percent shorter as compared to the Suez Canal. This results in time
and cost savings. Moreover, the Arctic is not being frequented by pirates that lurk off the coast of Somalia. (Thomas, 2010)

The year 2009 was labeled as a test year for vessels sailing from Europe to Asia and vice versa via the NSR. 2010 was marked as the breakthrough year as there are so many different shipping interests involved. Moreover, Russia and foreign shipping companies are coming to an agreement for using the NSR. The year 2011 will be seen as the take off year for commercial shipping along the NSR. (Thomas, 2010)

2010 saw 8 vessels of various specifications sailing through the NSR throughout the summer and autumn period. (BarrentsObserver, 2010) In 2011, BarrentsObserver (2010) reports that there will be an increase in voyages made along the NSR. Rosatomflot, the operator of Russia’s nuclear powered icebreakers, already has plans to escort up to 15 vessels of various types this year. The growing interest of the NSR taken by the public has paved the way for Northern sea ports to profile themselves as potential hubs in the future. Arrangements for Kirkenes in Norway, Murmansk in Russia and Petropavlovsk at Kamchatka in Russia’s Far East to become hub ports for the NSR are already on the way. (BarrentsObserver, 2010)

The increased in commercial shipping has proven that the NSR is no dream but a reality. It is important for coastal states like Norway and Russia to develop safety systems and joint emergency response teams as well as environmental monitoring to ensure safety at sea around the Arctic waters. It is also up to the authorities to cooperate with private sectors to come up with tighter sea regulations to minimize the impacts of global warming in the Northern sea areas. (Thomas, 2010)

3.2.3. Alternative Modes of Transport

Cargo transportation through the NSR is predicted by Murmansk authorities to increase by tenfold in 10 years time. Port infrastructure in Russia is presently underdeveloped and it would take time to improve the port facilities there. Another form of cargo transportation hitting the scene is the Trans-Siberian Railway built between 1890 and 1905. The main purpose of this railway was to connect Moscow with Vladivostok. Today, it is a major freight artery offering a fully developed container service from Europe to Far East linking major cities which includes Helsinki, Warsaw, St. Petersburg, Berlin, Beijing, Pyongyang, Seoul and Pusan (Russian Railways, 2007) transporting up to 130 million tons of cargo per year. (Boris, 2006)
This modern service allows full monitoring of trains and status of containers for customers to check on their cargo in real time to find out its current location and estimated time of arrival. Furthermore, security of these goods in transit is also constantly monitored. (Russian Railways, 2007)

The Trans-Siberian railway reduces up to two-third of the time taken to transport cargo by sea from China to Finland via the traditional Suez Canal. This reduces the number of days needed to transport the cargo to less than 10 days. Moreover, an added advantage of using the railway would be that it minimizes the need for transhipment, thus lowering the total cost of transporting cargo and the risk of accidental damage during the handling of goods. (Russian Railways, 2007)

Plans are being implemented to improve the railway system with 20,000 kilometres of new lines to be built by 2030. This is in effort to meet the apparent 70 percent increase in volume of goods. (Boris, 2006) In the future, connections via Siberia could be made to Taiwan, Australia and other East Asian countries. Thus the international significance of the Trans-Siberian railway between Far East and Europe will increase greatly by 2050. (Hugo, 2010)

Russia’s geography and climate limit the capacity of shipping in the Russian waters. Many Russian rivers run from South to North instead of East to West thus constraining their usage during the winter periods. Russia’s major ports such as St. Petersburg, Kaliningrad,
Novorossiysk and Sochi provide access to the Baltic Sea. (Photius, 2004) However, the state of infrastructure of these ports is still a far cry as compared to other world class ports in Rotterdam and Singapore.

Pipelines play an important role in distributing fuel to domestic consumption as well as for export to Europe. Europe’s energy security relies heavily on Russia’s oil and gas pipeline network. Russia transported a total of 48,000 kilometres of pipeline carrying crude oil, 15,000 kilometres of petroleum products and 140,000 kilometres of natural gas in 1993. (Photius, 2004)

![Figure 19: Main Oil and Gas Pipelines in Europe](source: Petroleum Economist (2011) BBC News)

The usage of pipelines is gaining significance after Russia has begun pumping 15 million tons of crude oil to China this year. This is stated in an agreement between the two countries which is said to last till 2030. The construction of this 999 kilometres long project has 72 kilometres in Russia and 927 kilometres in China. This pipeline will improve the structure of China’s energy imports and promote economic development. Moreover, the operation of the pipeline will improve China’s and Russia’s relationship thereby strengthening the economic foundation of the two countries. (ChinaDaily, 2011)
CHAPTER 4: METHODOLOGY

4.1. Introduction

Methodology is a set of practices often used widely across an industry or for a scientific discipline. (Smith, 2011) It includes the development of strategies when implementing research accurately. Precise specifications of the kind of results desired should be known so as to establish the most effective procedure to reach this target. (Babbie, 1989) In addition, a methodology is said to be a fundamental system of organizing principles for an area of study. It is a framework which allows knowledge to evolve as researchers can make use of the methodology framework to interpret existing information and to discuss new ideas, concepts and information. (All Answers, 2011)

Methodology encompasses everything that is crucial to a particular research being carried out. This includes philosophical approaches, theoretical models, rules on the created hypothesis, rules for the designing and conducting of relevant research as well as the collection and analyzation of data and results. (All Answers, 2011)

The choice of methodology should be related to the aim of the research and it must be acclimated to specific research situations pertaining to the root of the problem, research objectives and available resources. (Hellevik, 1980) It is important to have a defined methodology with clearly outlined directions and procedures to increase consistency. (Smith, 2011)

4.2. Research Approach

4.2.1. Experimental Research

Experimental research is defined as research in which the independent variable can be twitched to alter an effect. It allows researchers to establish, with some certainty, causal relationships between variables. Researchers using this method should have a good degree of control throughout the period of study to establish the cause and effect of the experiment. (Psychology Glossary, 2011)
A classical experimental approach involves assigning subjects at random to either an experimental or control group. The experimenter manipulates the conditions for the experimental group to assess their effects in order to make a comparison with members of the control group which are not subjected to any unusual conditions. (Ramberg, 2000)

Quasi-experimental design is developed after some researchers recognized the practical difficulties of producing pure experimental designs. Campbell and Stanley (1963) brought about the pre-test/post-test comparison design which reduces the effects of control and experimental groups not being fully matched. This is done by evaluating a range of designs which adopt multiple measures over time.

4.2.2. Survey Research

Survey research represents one of the most important areas of measurement in applied social science research. This method is used to obtain data in a structured manner directly from a sample of respondents from a population by administering a standardized questionnaire. The survey can be a written document completed online, face-to-face, or through a telephone interview. (Colorado State University, 2011)

The main objective of a survey is to obtain information from a defined set of people. However, it is not always possible to gather everyone in a population to obtain a result. This is known as sampling methods. A sample is a sub-set of a population which fully represents the main areas of interest of the population. An observed pattern that is statistically inferred from the sample could be then replicated to the population. (Ramberg, 2000) The main advantage of this method is that it is relatively inexpensive. (Sudman, 1976)

4.2.3. Case Research

Case research or case study research is a strategy used to obtain information from one or a few situations that are similar to the problem that the researcher is facing. This is done by conducting a case study which requires the cooperation of the party whose past is studied. Intensive interviews or discussions are often carried out. (Yin, 1989)
Case research accentuates the detailed analysis of a restricted number of events or conditions and their relationships. This method is applied by researchers across various disciplines for many years. This is especially so for social scientists who have employed this qualitative research method to examine existing situations and to provide a platform for the application of ideas and methods. Researcher Robert K. Yin (1989) defines the case research as a practical inquiry that examines an existing phenomenon within its real-life context. It is when the boundaries between phenomenon and context are not evident, and where multiple sources of evidence are present. (Susan, 2006)

Moreover, through the means of intensive interviews and discussion with key informants of the chosen case, the case research method gives the researcher flexibility to seek in-depth understanding of the research questions. It also allows the researcher to identify individual informants from each chosen case. Informants vary from case to case, and can be found through cross referral or identified during interactions. (Ramberg, 2000)

The case research method is the only approach which allows for such in-depth research of information. It allows respondents to express their views and opinions freely during the interview and discussion processes. This is kept confidential so as to further encourage greater input from the respondents necessary for the study. (Ramberg, 2000)

Critics of this research method believe that there is no reliability in the findings established due to the study of a small number of cases. However, researchers who continue to use the case research method are successful in carefully planning and crafting studies of real-life situations and problems. (Susan, 2006)

4.3. Research Design

4.3.1. Case Study: The research approach

The ice in the Arctic is reducing due to global warming. Already today ships can pass the Northern Sea Route (NSR) 2-3 months a year. In a perspective of 50 years a new passage along the Siberian coast might be a reality. How will this scenario affect Singapore as a major HUB? How can the maritime industries develop proactive strategies and take advantage of the new business opportunities?
The case research method is the choice of research approach for this paper. This method answers the three conditions of a research question mainly how, what and why. Moreover, the case research method only focuses on contemporary events and does not require any control over behavioural events. Yin (1989) stated that the case research is an important method used to answer a “how” or “why” question asked during a contemporary set of events over which the investigator has little or no control.

It is important to take note that the last two steps of the process which links the data to propositions and the identification of criteria for interpretation are still considered as weak points in a case study research. (Yin, 1989)

### 4.3.2. Cases in the Empirical Research

The following interviews and research form the basis for the empirical part of this research paper:

- Interview: Mr. Joshua Ho, a senior fellow in S. Rajaratnam School of International Studies based in Nanyang Technological University (NTU). He wrote two articles on the NSR and how the Arctic meltdown could hurt Singapore respectively in 2009
- Interview: Mr. Soh Woei Liang, General Manager of Glory Ship Management
- Interview: Mr. Geir Fuglerud, Principal Consultant for DNV Clean Technology Centre
- Interview: Mr. Jan Erik Schulte, Head of Operations in Beluga Shipping
- Interview: Mr. Lie Sek Guan, Research and Statistics Manager in the Commercial Department of PSA Corporation
- Interview: Mr Teh Kong Leong, Lecturer at NTU
- Email Correspondence: Miss. Liu Miao Jia, an assistant professor from Erasmus University. She recently published a research article on the potential economic viability of using the Northern Sea Route as an alternative route between Asia and Europe in 2010.

The following personnel or organization was approached but an input from them could not be reached for this research paper:

- IE Singapore
• Maritime and Port Authority of Singapore (MPA)
• Assistant Professor Koh Tieh Yong of the School of Physical and Mathematical Sciences, NTU. He is a principal investigator on climate science at the Earth Observatory of Singapore (EOS)
• APL Co. Pte Ltd
• Lukoil Asia Pacific
• Keppel Corporation
• Portek International Limited

4.3.3. Objective

The objective of this research paper is to do a background study on the respective work packages and their impacts on Singapore. Moreover, propositions on new business opportunities for the Singapore maritime industry will be proposed in view of the opening of the NSR.

4.3.4. Research Questions

The study of the following research questions is to be used to enhance the purpose of this research paper.

• What are the consequences of Global Warming on the Arctic?

• What lies ahead in the year 2050?

4.3.5. Limitations

Firstly, this research paper is purely a theoretical paper which does not include any detailed calculations. Thus the findings and conclusion made to this paper may not provide a full picture.

Secondly, the author faces an inability to collect comprehensive data from various sources as these required data are considered private and confidential to the respective companies and governmental bodies approached.
Thirdly, despite dividing the research topic into 6 respective work packages, a correlation between these 6 work packages is not achieved.

Lastly, the timeframe for this prediction is too far for the author to make a firm statement with regards to the proposed opportunities for Singapore Maritime industry.

CHAPTER 5: EMPIRICAL RESEARCH

5.1. Impacts of Global Warming on the Arctic

5.1.1. Proposition

The Arctic will be completely ice-free all year round by 2050.

5.1.2. Degree of Arctic Ice Melt

The controversy over climate change has heightened over the past decade which led to the growth of Arctic climate talks in recent years. The Arctic consists of large ocean surrounded by islands whereas the Arctic Ocean is covered in ice all year round, with snow and ice present on land for most of the year. (National Snow and Ice Data Centre, 2011) However, in recent years, the Arctic Ocean is unlike what it used to be. The summer period in 2007 saw the most disastrous ice melt with ice extent in the Arctic hitting the lowest accord of 4.3 million square kilometres. (Earth Observatory, 2010)

Researchers have been coming up with various scenarios to take into account the degree of Arctic ice melt and how this would have an impact on shipping. Many research papers on the Arctic have surfaced. These include the feasibility of the different Arctic routes to the development of new Arctic technology which could enable present commercial vessels to ply the Arctic routes.

Joshua Ho, a senior fellow in S. Rajaratnam School of International Studies based in Nanyang Technological University (NTU) has written two articles on the NSR and how the Arctic meltdown could hurt Singapore respectively in 2009. An interview with him on his views for a
completely ice-free Arctic by 2050 was rather negative. He added that if this phenomenon were to occur, Singapore should be very concerned about the rise in sea level across the entire globe. As Singapore is situated on a low lying area, it is possible that flooding would occur. Worrying about trade volumes in Singapore ports being diverted to the Northern region should not be the main concern. This is surprisingly agreed upon by Geir Fuglerud from DNV and Soh Woei Liang from Glory Ship Management.

Additional information and opinions on the degree of Arctic ice melt could not be reached after a declination by Assistant Professor Koh Tieh Yong of the School of Physical and Mathematical Sciences, NTU. He plays an important role in this research as he is a principal investigator on climate science at the Earth Observatory of Singapore (EOS). (Earth Observatory of Singapore, 2010)

5.1.3. Verification of Proposition

The Arctic will be completely ice-free all year round by 2050.

After the views and opinions from commercial personnel and researchers are sought, it is evident that they do not think that the Arctic would be completely ice-free by 2050, although interest spurred from talks about the NSR is apparent. The NSR may not be completely ice-free by 2050 but there are clear signs that the opening period of the NSR could be prolonged.

Estimates were not given by the respective interviewees as stated above with regards to their outlook as they claimed they were not experts in this field. Thus as forecasted by Liu and Kronbak (2010), the NSR could be open for 120 days in 70 years time with the present opening period of only 20 – 30 days.

It is important to understand the impacts of a completely ice-free Arctic all year round and the damage that it can bring about. Analyzing and understanding this could take more than 40 years. The world should rejoice to the fact that the Arctic will still be partially covered in ice by 2050.

The proposition is invalidated.
5.2. Looking Ahead into 2050

5.2.1. Proposition

The world would adopt alternative sources of energy like gas and renewable to cope with the rising energy demand. Moreover, the Arctic region would see an increase in the amount of trade using vessels, rails, and pipelines catered to their most efficient form of usage.

5.2.2. Alternative Sources of Energy

Energy is needed to drive economies. As world population spikes upwards and economies developing at a rapid pace, the demand for energy is undeniable. With rising energy demand, coupled with rising oil prices, the day for oil to be substituted is not far. Furthermore, debates over the responsibility of increasing carbon emissions leading to global warming and resulting in worsened climate changes has led to international treaties and agreements making an effort to reduce carbon emissions and hopefully slow down the impacts of climate change.

An interview with Principal Consultant for DNV Clean Technology Centre, Geir Fuglerud, introduced the possibility of adapting the Triality Concept into Arctic-going vessels. Triality is a new crude oil vessel concept developed by DNV as an innovation project. The vessel is said to be fuelled by LNG and has a hull shape that removes the need for ballast water. This concept vessel is a major step towards a new era of having a cleaner and greener environment for the tanker shipping industry. Moreover, DNV CEO, Henrik O. Madsen, said he is convinced that gas will become the dominant fuel for merchant ships by 2020. (Richardsen, 2010)

Geir was also supportive of this idea and said that the rising oil prices would drive the industry to switch to gas as an alternative. However, he stated that it would take about 20 years for this concept to be accepted by the industry and that international regulatory framework would quicken this process through the promotion of a cleaner environment. In his opinion, he felt that the Arctic would not be completely ice-free all year round by 2050 and that it would take a much longer time for that to occur although there are signs that the Arctic region is melting at an exceptional rate.
As of now, there are too many risks involved for vessels to be plying through the Arctic using the NSR and some of his concerns are in relation to the search and rescue in the Arctic, crew working in extreme cold temperatures and oil spills.

During a talk held at NTU this year on the topic of “Green Ports and Shipping”, Visiting Professor Bengt Ramberg also made a remark that there will be an increasing demand for natural gas in the next few years. Given that natural gas emits a relatively low greenhouse gas emission and is a one of the safest and cleanest source of energy, it will take up higher percentage in the overall energy pie.

5.2.3. Increasing Trade in the Arctic

The NSR is said to be gaining popularity among ship owners. When told of the significant reduction of about 22 percent to 40 percent in sailing distance the NSR could save, General Manager of Glory Ship Management, Soh Woei Liang, welcomes the idea. However, he added that it was more about the dollars and cents when it comes to a decision made by a ship owner. A rough calculation on the operation costs for a vessel to ply the NSR should be calculated and compared against the costs it would take a vessel plying the Suez Canal. It is important to take note of the port charges as well. Soh had some apprehension towards this idea in terms of the hidden cost for a vessel using the NSR which include the cost of hiring an ice breaker, delays in ports and administrative work resulting in waiting costs. Moreover, he brought up the point of understanding trade patterns. It is important to understand trade patterns and where goods are produced and consumed as this would be a crucial factor in deciding the route for which a vessel is to take.

However, if the NSR were to be ice-free and ice breakers are not needed, there could really be savings in operational costs as the route is much shorter. The NSR would then be more appealing to ship owners. Soh added that there is growth potential for the Northern region but it all boils down to the cost factor needed to persuade a ship owner to choose the NSR.

One event that made history was when two of Beluga Shipping’s multipurpose heavy lift carriers, the MV “Beluga Fraternity” and the MV “Beluga Foresight” transited the NSR from Asia (Ulsan, South Korea) to Europe (Navvy, Yamburg). During an interview with Beluga Shipping, Head of Operations - Jan Erik Schulte claimed that a total of US$300,000 per vessel was saved by transiting the formerly ice covered route along the North Russian shore through
the Bering Sea, the Bering Straits, the Laptev Sea, the Vilkitsky and the Kara Sea instead of the
traditional Suez Canal. Moreover, environmentally harmful emissions were significantly
reduced through the reduction in bunker consumption.

Jan pointed out that Beluga had good contacts with the Russian government which gave them
the green light for the transit through the NSR. Moreover, the MV “Beluga Fraternity” and the
MV “Beluga Foresight” both had a full Russian crew headed by a Russian master onboard.

At present, the Russian government holds fort to the number of vessels transiting through the
Arctic waters with Rosatomflot planning to escort up to 15 vessels of various types this year
through the NSR. (BarentsObserver, 2010) More vessels are likely to transit through the NSR
given that the opening time frame in summer is prolonged as the variability of ice covered
passages is reduced. Infrastructure and ports along the NSR is another factor deterring
commercial vessels from transiting through the NSR. Remarks by Jan noted that port conditions
were poor and there were inadequate land logistics to support the amount of trade.

Through an email exchange with Liu Miao Jia, an assistant professor from Erasmus University,
she too stated that there is limited infrastructure and port facilities along the Siberian coast and
that there are practically no port facilities from Western Siberia to Russia’s Pacific coast. Liu
views that the NSR will become a popular shipping route but it would take more than 40 years
for this to happen given the state of infrastructure in that region.

According to Jan, specialized cargo like project cargoes will be the most advantageous type of
cargo to ply the NSR as vessels can make direct calls from one port to another. This statement is
also supported by Geir from DNV as he felt that project cargoes would suit the overall
conditions and trade patterns of the NSR.

5.2.4. Alternative Modes of Transport

Shipping goes a long way back into history and is an old industry fit for the purpose of carrying
goods around the world. Around 90 percent of world trade is transported by sea. (The
Honourable Company of Masters Mariners, 2008) Without shipping, the import and export of
large scale goods across the globe would not be possible. As seaborne trade continues to expand,
the world will see larger ships being built giving rise to economies of scale and further growth
for the industry. (The Round Table, 2011)
Although the shipping industry is going strong, other modes of transportation are also caught up in the race. With the advancement and improvement of technology, not only are ships getting larger and more efficient, railway systems and pipelines are also better developed. Sea transportation enjoys the largest economies of scale when comparing its cost per unit load with other modes of transportation such as rail and road. However, the Trans-Siberian Railway is seen as a strategic alternative to the partially ice covered shipping lanes in the Arctic. It takes an average of 45 days to ferry goods from Asia to Europe via the Suez Canal but only takes 15 days via the Trans-Siberian Railway. Transiting through the NSR would take up to 35 days depending on the ice conditions. Future plans to develop the railway system to become a major player in international container traffic competing with sea routes are in the making. (Miriam, 2007)

During an interview with Jan from Beluga Shipping, he mentioned that by improving the Trans-Siberian Railway into a double-stacked train, it could be possible for the railway to be price competitive against sea transportation.

Pipelines are the most efficient mode considering that oil and gas is constantly being pumped while ships, rails or cars could break down and be delayed. However, there are many issues that need to be considered especially security. Tankers spent more of their time sailing in the middle of the ocean, being only vulnerable to pirate attacks near coastal areas. Pipelines on the contrary, are vulnerable and difficult to guard as it depends on the political stability and law enforcement of the state in which any part of the pipelines were to be laid. Pipelines also face the problem of maintenance due to wear and tear. The issue of ownership and cost issue is a thorny one. (Bimco, 2006)

In addition, the comparative cost of a pipeline should be taken into consideration. The cost of a pipeline depends on a variety of matters other than steel price and labour costs. The effort taken to transport the pipelines and pumping stations to the site is a problem. Terrain and any environmental constraints over routeing will only add to the cost. Expensive sub-sea work, pipe lay and regular inspection should be factored in if the pipes have to cross seas. Tankers may be cheaper than pipelines, even though they require expensive port facilities and initial capital costs. Nevertheless, pipelines will have an important role to play in the foreseeable future. (Bimco, 2006)
5.2.5. Verification of Proposition

With rising concerns over global warming and climate change, the world would adopt alternative sources of energy like gas and renewable to cope with the rising energy demand. Moreover, the Arctic region would see an increase in the amount of trade using vessels, rails, and pipelines catered to their most efficient form of usage.

It is evident that the demand for gas and renewable energy will be on the rise for the next few decades while the demand for oil will slow down after the next decade. With ever increasing oil prices and stronger climate enforcing policies, demand for oil may take a turn although the change is not immediate.

Expanding economies and increasing world trade will be the driving force behind cost savings routes like the NSR. Transiting via the NSR would reduce time and cost as compared to sailing through the Suez Canal to get from Far East to Europe. Rosatomflot, Russia’s nuclear ice-breaker fleet has got up to 15 orders consisting of cargo vessels and bulk carriers for assistance this year. (BarentsObserver, 2010) This shows that the NSR is gaining popularity and this is good news for Russia who currently holds fort over the usage of the NSR. However, Russia needs to improve its port infrastructure and logistics network around that region to support the increase in cargo transportation through the NSR as predicted by Murmansk authorities. (Russian Railways, 2007)

With the advancement and improvement of technology, railway systems and pipelines are getting better developed. Although sea transportation enjoys the largest economies of scale, the Trans-Siberian Railway is seen as a strategic alternative to the partially ice covered shipping lanes in the Arctic. This would facilitate cargo flow from Europe to Far East and could one day reach out to countries like Taiwan and Australia.

Pipelines are also another alternative seen to transport oil and gas out of Russia. With the US Geological Survey 2008 estimating that the amount of undiscovered Arctic oil and gas to be worth 90 billion barrels of oil, 4.4 billion barrels of natural gas liquids and 1,670 trillion cubic feet of natural gas (Donald and Brenda, 2008), pipelines could just be the solution to ease the export flow of these resources.

The proposition is validated.
5.3. Impact on Singapore

5.3.1. Introduction

Singapore is a small island geographically located at a strategic position. With a total land area of only 682.7 square kilometres, (Newasia-singapore.com, 2010) Singapore is a global hub port connecting more than 600 ports in over 120 countries and is considered to be one of the busiest ports in the world in terms of shipping tonnage. Singapore offers a global network and connectivity with a complete range of services such as ship management, finance, insurance, legal, and education, thus offering the shipping industry a one stop solution. (Maritime and Port Authority of Singapore, 2009)

Renowned for its transhipment services, Singapore has more under her belt. She is also one of the top bunkering ports in the world selling more than 30 million tonnes of bunkers annually. Moreover, Singapore is accredited for being the world’s third largest oil refinery and trading hub. Presently, Singapore holds 70 percent of market share in jack-up rig building and 65 percent of market share in floating production and storage offloading (FPSO) conversions. (Maritime and Port Authority of Singapore, 2009)

The Maritime and Port Authority of Singapore (MPA) aims to position Singapore as an International Maritime Centre (IMC). MPA is working to attract ship owners, operators and maritime services providers to set up operations in Singapore so as to create a pro-business environment. (Maritime and Port Authority of Singapore, 2009) Singapore’s open trade economy made her sensitive to external market forces. Any form of political or environmental forces could have an impact on Singapore.

5.3.2. Impacts of Global Warming on the Arctic

There is a growing concern that Singapore will be affected by the Arctic meltdown resulting in the opening of new Arctic sea lanes which could divert sea traffic there. The impacts of global
warming and climate change have caused significant consequences on the Arctic. The Arctic which was once impenetrable is presently open for about 20 – 30 days during the summer months as ice is melting at an exceptional rate. This opened doors for commercial shipping as vessels are able to transit through the Arctic via the NSR. Oil and gas explorers are too rejoicing as this would pave the way for exploration in the Arctic which has bountiful resources.

To further understand this situation and how it would impact Singapore, a comparison between the distances of Rotterdam to various other ports (via different routes) is made. Most research papers use ports in Rotterdam and Yokohama as their points of reference to show that the sailing distance between these two ports via the NSR is much shorter. Sailing from Yokohama to Rotterdam via the NSR totals a distance of 7,825 nautical miles while transiting through the traditional Suez Canal takes a total distance of 11,212 nautical miles. However, this does not accurately portray that transiting through the NSR is always beneficial to all.

Assuming a start point in Hong Kong and an end point in Rotterdam as shown in Table 2, the total distance via the Suez Canal is only 8,859 nautical miles while the total distance using the NSR totals to 9,410 nautical miles. Hence this shows that the NSR is not beneficial to all ports situated in the Far East or Europe region. Detailed calculations should be done before deciding on the route for which a vessel is to take.

<table>
<thead>
<tr>
<th></th>
<th>Shanghai</th>
<th>Busan</th>
<th>Hong Kong</th>
<th>Yokohama</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance</td>
<td>Time</td>
<td>Distance</td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td>Nautical</td>
<td>Days</td>
<td>Nautical</td>
<td>Days</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>13,889</td>
<td>27.6</td>
<td>14,209</td>
<td>28.2</td>
</tr>
<tr>
<td>- Cape of Good Hope</td>
<td>13,161</td>
<td>26.1</td>
<td>14,506</td>
<td>28.8</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>9,612</td>
<td>19.1</td>
<td>9,907</td>
<td>19.7</td>
</tr>
<tr>
<td>- Suez Canal</td>
<td></td>
<td></td>
<td>8,859</td>
<td>17.6</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>8,855</td>
<td>17.6</td>
<td>8,490</td>
<td>16.8</td>
</tr>
<tr>
<td>- Northern Sea Route</td>
<td></td>
<td></td>
<td>9,410</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7,825</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Table 2: Distance in Nautical Miles and the Sailing Time in Days from Rotterdam to Four Ports in Asia via Three Shipping Routes

Source: Almar (2010) An Arctic Dream-The Opening of the Northern Sea Route: Impacts and Possibilities for Iceland

Table 3 shows the tabulation of the top 10 container shipping lines taking into account the total number of shipping routes within the Far East – Europe trade. Vessels taking these routes will call at a number of ports throughout the entire route but only the stop-over made in Singapore is accounted for. By having a simple analysis, more than 50 percent of the total Far East- Europe
trade route bypasses Singapore. This shows that Singapore is a prominent hub port in this region and that trade will not be easily diverted over to the Northern Region.

Moreover Maersk Line, the largest container shipping company provided feedback that ports located around Singapore, including ports in Singapore do not have to be worried that container shipping will be diverted to the Arctic region. This is because container shipping is supported by the hub and spoke concept. A container vessel calls at a hub port to load and unload its goods, while feeder vessels will distribute these goods to surrounding ports in that area. Only goods that are directly shipped from point to point such as special project cargoes will benefit from the shorter distance via the NSR.

This is coupled with the fact that Singapore is a transhipment hub and that the country is too small to make any impact on world export and import, Singapore will not be threatened with the opening of the NSR as she will not be very much affected by it. Although the NSR offers a much shorter route, the trade pattern for container shipping is unlikely to be affected by this as vessels make profits by calling at a few ports along their voyage loading and unloading cargo.

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share [%]</th>
<th>Total no. of routes [Far East - Europe Trade]</th>
<th>No. of routes bypassing Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maersk</td>
<td>14.7</td>
<td>29</td>
<td>7</td>
</tr>
<tr>
<td>Mediterranean Shipping Co</td>
<td>12.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CMA CGM Group</td>
<td>9.1</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Hanko Lloyd</td>
<td>4.1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Evergreen Line</td>
<td>4</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>APL</td>
<td>2.8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>CSCL Group</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>COSCO Container Line</td>
<td>3.7</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Hanjin Shipping</td>
<td>3.4</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>CSCL</td>
<td>3.1</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3: Top 10 Container Shipping Companies’ Respective Market Share and Number of Routes Bypassing Singapore

### 5.3.3. Looking Ahead into 2050

The year 2050 is too far ahead for anyone to make an accurate forecast. However, future plans which are currently on the table provide a glimpse of Singapore’s plans 40 years later.

As countries strive to decarbonise their energy mix, natural gas will continue to play an important role. Natural gas is considered to be the fuel of the future. Shell has plans for half of its output to come from natural gas by 2012 while 7 out of 8 Exxon Mobil projects were for
natural gas developments. Singapore is in a very good position to become a LNG trading hub since she is Asia’s top oil trading centre even though Singapore does not own any oil. (EnergyAsia, 2011)

Singapore plans to build a third tank at the proposed LNG terminal in efforts to become a trading hub for LNG. The terminal would also provide an array of services such as storage and sale of industrial gases such as LPG and LNG as bunkering fuel for ships in the future. (EnergyAsia, 2011)

Singapore aims to become a renewable energy powerhouse too by encouraging research and development (R&D) in renewable energy as well as attracting renewable energy companies to set up operations here. Three companies in Singapore, Natural Fuel, CMS Resources and Neste Oil have pledged to a total production capacity of 2.8 million tons in bio-fuel production annually. (Low and Cheong, 2008) With efforts to tap into cleaner energy, Singapore could achieve her ambition to become a cleaner and greener nation by 2050.

5.3.4. Conclusion

Singapore is hardly visible on the world map but she is known for great things. Singapore’s open trade economy makes her vulnerable to external market forces and any political or environmental forces could trigger an impact on Singapore’s economy.

With the Arctic ice melting at an alarming rate, fears that trade volume would be diverted to the newly opened Arctic route - the NSR, was brought up. It is evident that sailing from Yokohama to Rotterdam would result in distance savings of almost 4,000 nautical miles. However, all things should not be taken at face value.

The NSR is not beneficial to all ports situated in the Far East or Europe region as shown by the comparison done above. Thus further research and calculation should be done before a ship owner decides on the exact route travelled by the vessel.

A summary of the top 10 container shipping lines, taking into account their total number of shipping routes in the Far East – Europe trade shows more than 50 percent of the total Far East – Europe trade route bypasses Singapore. This shows that Singapore is a prominent hub port for this region. Moreover, a container shipping line makes profits by calling at a few ports during
their voyages loading and unloading cargo. Hence, cargo volume in Singapore is unlikely to drop even after the NSR is opened as container trade pattern flow between hub and spoke does not allow that.

In 2050, it is possible for Singapore to achieve her aim of being a green Singapore. With countries striving to decarbonise their energy mix, Singapore aims to become a LNG trading hub and a renewable energy powerhouse. Plans to build a LNG terminal providing an array of services like LNG bunkering stations for ships are on-going. In addition, companies in Singapore have pledged to an annual total production capacity of 2.8 million tons in bio-fuel production to meet rising energy demand.

Although it is tough to have an accurate forecast of the year 2050, future plans and discussions provide a glimpse and glimmer of hope that Singapore is moving towards a cleaner and greener nation.

5.4. New Business Opportunities

5.4.1. Proposition 1 – Port Investment in Russia

Interest in the NSR is intensifying as satellite dishes show pictures of the diminishing ice extent in the Arctic. Discussions were raised over the opening of the Arctic region to international trade. If oil and gas resources in the Arctic region could be tapped, this could bring about trade in Russia. With the increasing hype over this issue, Russia’s port sector is attracting increasing interest from foreign investors. Russia’s finance minister, Alexei Kudrin, announced at a Moscow conference aimed at promoting the nation as a global business hub that foreign direct investments (FDI) in Russia is expected to amount up to US$40 billion this year and is projected to grow at least 25 percent next year. (Bruce, 2010)

Investors in Singapore are not letting this opportunity slip. Seven Memoranda of Understanding (MOU) have been signed this year to strengthen ties between Singapore and Russia (Cheng, 2010). ME Projects and Europort International, which are subsidiaries of CWT and Portek respectively, signed a MOU with Russia’s JSC Vladmorrybport. The objective of this MOU is to evaluate the feasibility of transforming the Far Eastern Vladivostok Sea Fishery Port into a strategic modern container port. This is significant in linking the commodity-rich Russian
hinterland to Siberia. Through the input of technological and logistics know-how, in addition to the strengths from both companies, it is predicted that the number of containers handled each year will triple in volume. (Lynn, 2010)

Portek has also signed a similar MOU with Mariel Refinery Group. The viability of developing, managing and owning a port in a new industrial park in Kaliningrad is being studied. Further projects between Singapore and Russia are also coming along with Keppel Corporation bidding for a waste management project in St. Petersburg (Lynn, 2010).

In addition, as reported by Russian News Agency, Ria Novosti, the NSR is said to become a major Eurasian transshipment route in the next few years due to the shorter distance between Russia and Japan (Ria Novosti, 2007).

In view of the increasing trend in investments being invested in Russia, more investments will naturally follow. With Europort International Pte Ltd setting an example of venturing into Russia, Singapore’s leading global port group, like PSA International could follow suit and make use of this opportunity to tap into the Russian market. PSA International has investments in 28 port projects in 16 countries across Asia, Europe and America (PSA Singapore, 2010) with no current projects situated in the Arctic region or near Russia.

Figure 20: Map of the 28 Port Projects by PSA International
Source: PSA International, 2010
An interview with Lie Sek Guan, Research and Statistics Manager in the Commercial Department of PSA Corporation, confirms that it might be possible for PSA International to venture into that region. He added that intensive research must be done before this decision is made ensuring that the region is of a non-saturated market so as to enjoy a high profit margin.

Thus it is a possibility that PSA International would build a port facility along the NSR. When this is a reality, the option of building an oil terminal or oil refinery upon the port could be possible. Singapore being one of the top bunkering ports in the world could consider setting up a trading hub in that region too.

The proposition is validated.

5.4.2. Proposition 2 – Consultancy Services

PSA Singapore is renowned for being one of the world busiest transhipment hubs with about one-fifth of the world’s total container transhipment throughput. Moreover, PSA is constantly very innovation in automation and the use of intelligent systems to enhance its competitiveness. PSA has developed applications such as Computer Integrated Terminal Operations System (CITOS®) and PORTNET® which gave it an edge over its competitors to achieve higher levels of productivity and efficiency. In addition, PSA leverages on technology to ensure high security levels throughout its operations without disrupting day-to-day operations. (PSA Singapore, 2010)

Thus, PSA is in a very good position to provide consultancy services to port operators intending to extent and improve their operations along the NSR. This proposition is supported by the Research and Statistics Manager from PSA noting that this could be possible. Consultancy services such as port building, port management and port planning could be extended to port operators and a consultancy fee is charged upon these operators.

The proposition is validated.

5.4.3. Proposition 3 - Education

Having a basic education could go a long way and it is important for the younger generation to have a solid foundation. In Singapore, an education in shipping could be found at various
institutions such as Nanyang Technological University (NTU), National University of Singapore (NUS), Singapore Maritime Academy (SMA), Singapore Polytechnic (SP) and many more. (Maritime and Port Authority of Singapore, 2007)

Besides promoting the maritime industry in Singapore, this is in effort to educate prospective personnel into the shipping sector. Presently, NTU has collaborated with BI Norwegian School of Management in an effort to improve the current Maritime Studies curriculum for both the Bachelor and Masters Program. This joint program provides young graduates and middle-management executives a chance to study abroad in Norway where they learn and gain a deeper understanding of the maritime business.

As Russia gains prominence in the world today, there has been an increased interest in the culture and traditions of Northern Russia. Educational institutions such as NTU should consider collaborating with educational institutions in Russia where local students can exchange cultural experiences and knowledge. Moreover, a tripartite relationship with Murmansk State Technical University (MSTU), BI and NTU could be formed to further improve relations as well as knowledge in the shipping sector. MSTU is the oldest, technical state-owned education institution in the Murmansk region. It is also a collective member of the Russian Transport Academy, Engineering Education Association of Russia and Association of Technical Universities. MSTU welcomes international educational cooperation and has programs such as international summer school. (MSTU, 2008)

In addition, students from these three universities can embark on cross internship programmes with local companies from these respective countries to gain insightful international working experience. This will enhance deeper cultural and economic understanding. In view of the opening of the NSR, the network formed from the result of these joint programs between the universities can lead to business, projects and research opportunities in the future.

This proposition could be further looked into by other educational institutions in Singapore and not just by the above mentioned institutions. The names are provided as a reference with regards to the opportunities which could be taken advantage of when the Arctic becomes ice-free in 2050.

The proposition is invalidated.
5.4.4. Proposition 4 – Arbitration Hub

Singapore is emerging as an all rounder in the Marine sector and legal is definitely one of the arms. As Singapore thrives to be the centre of maritime legal expertise, offering a comprehensive legal framework, the Singapore Chamber of Maritime Arbitration (SCMA) is set up to promote and provide maritime arbitration which is responsive to the needs of the maritime community. (Maritime and Port Authority of Singapore, 2009)

The recent launch of the Singapore Ship Sale Form (SSF) shows the growth potential of Singapore becoming involved in the legal side of things in the Maritime sector. The SSF is an alternative form that would cater to the needs of Asian’s Maritime sector. There have been increasing maritime activities and maritime arbitration cases in Asia and thus in time to come, Singapore could become a renowned Arbitration Hub. (Singapore Maritime Foundation, 2011)

Arising territorial claims made by the five Arctic coastal states namely the United States, Canada, Norway, Russia, and Denmark, over their wants to seize control of the Arctic’s resources, could see Singapore rising on the ranks to become an Arbitration Hub. With Singapore’s stand on being a neutral nation, she could be seen as the preferred jurisdiction for the Shipping and Energy business around the Arctic Region.

The proposition is invalidated.

5.4.5. Proposition 5 – Ship Building

In 2006, Keppel Offshore and Marine Ltd (O&M) signed an agreement with LUKOIL to cooperate in the newbuilding of offshore rigs, special purpose offshore facilities and vessels (Yard News, 2006). As of 2009, 2 ice breakers, 2 ice classed Anchor Handling Tug Supply vessels, 2 ice classed rescue vessels and an ice classed Floating Storage and Offloading vessel (FSO) were delivered to LUKOIL. (Keppel Corp, 2009)

Keppel O&M was the first Asian country to design and build ice classed vessels according to the standards and rules of the Russian Maritime Register of Shipping (RMRS), a member of the International Association of Classification Society. (Yard News, 2006)
LUKOIL is a leading Russian oil company whose main activities are oil and gas exploration and production as well as production and sale of petroleum products. LUKOIL – Nizhnevolzhskneft (NVN) is involved in the exploration, development and production of oil and gas in the Southern Russian Federation: Astrakhan, Caspian Sea and Azov Sea. (Keppel Corp, 2009)

This cooperation signifies a form of synergy forged between Singapore and Russia. In 2007, Russia has released plans to build 40 ice resistant oil platforms, 14 offshore gas terminals, 55 ice resistant tankers and storage tankers and 20 gas carriers. (Ria Novosti, 2007)

Keppel has shown that it is possible for maritime companies in Singapore to establish a working relationship with counterparts in Russia and thus this could be the first step towards future collaborations. The Arctic is predicted to be ice-free by 2050 and thus ice classed vessels are still required for exploration in the Arctic. Hence companies involved in ship building could use this opportunity to expand their businesses into Russia.

This proposition is invalidated.

CHAPTER 6: CONCLUSION

In the last few decades, research has revealed that humans have a powerful influence on the climate. Today, international talks on global warming and climate change are perhaps the most sensitive and complicated issue facing world leaders. On one hand, warnings from the scientific and research community of rising dangers from increasing human-related greenhouse gases, mainly produced by the burning of fossil fuels, are becoming louder. While on the other hand, economic and political issues have to be resolved before a worldwide effort to reduce greenhouse emissions is made possible. Nations are torn between the need for economic growth and the rising issues of global warming. (The New York Times, 2011)

Global warming and climate change is a hot topic amongst international leaders and nations today. The impacts of climate change are most prevalent in the Arctic and this has caught the eye of many. The Arctic which was covered in ice caps and glaciers was once impenetrable by humans. However, due to the impacts of global warming and climate change the Arctic is now opened for a period of about three weeks. (Larry, 2010)
The Arctic is shrinking at an alarming rate of 12.9 percent over a span of 11 years. (Earth Observatory, 2010) If this rate were to persist, the Arctic would be ice-free by 2050 and this would give way to a more accessible Arctic. (Anthony, 2008) On the contrary, a diminishing Arctic would endanger the habitat of Arctic animals living there pushing them to extinction. (Susan, 2004) Thawing of the permafrost layer could also destabilize existing infrastructure resulting in frequent replacement and maintenance. Moreover, bacteria and fungi would breakdown carbon contained in the soil when the ground thaws, releasing additional greenhouse gases into the atmosphere. (Aaron, 2008)

Presently, three main Arctic routes, mainly the Northern Sea Route (NSR), Northwest Passage (NWP) and the Central Arctic Ocean Route, provide the gateway across the Arctic. The NSR is presently the most feasible and viable option. Cargo transportation is possible along the NSR during the summer months, from the beginning of July to the end of October. Figures from the ACIA indicate that the sailing season along the NSR could be prolonged from the current 20 – 30 days to about 120 days by 2080. (Ragner, 2008)

A savings in time and costs is achieved due to a 22 percent reduction in distance from the usage of the NSR. (Badari, 2010) Although sailing along the NSR brings about many benefits, it is important to consider the navigational challenges too. Hence precautionary efforts should be in placed when transiting the NSR to fully enjoy the benefits of it.

Energy is the lifeline of modern economies, providing reliable energy to fuel technologies and services in developed countries while improving developing countries’ way of life by supporting their economic and population growth. (ExxonMobil, 2010)

The rising economic powerhouses of China and India will cause a surge in demand for oil with China predicted to become the world’s second largest oil consumer after the United States. (Michael, 2011) However, on the supply side, this has not been increasing in proportion with the demand of oil.

The price of oil is dependent on the world supply and demand and the imbalance of these two sides is causing oil prices to peak to at high of USS500/MT (Bloomberg, 2010). With the ever increasing oil prices and increasing concern in climate policies, the world could be heading to an alternative source of energy soon.
Natural gas, being one of the safest, cleanest, and most useful sources of energy with a relatively low greenhouse gas emission could become the next fuel to our economy in the future. It accounts for 22 percent of the world’s energy mix and its demand is growing especially in OECD nations. (NaturalGas, 2010) Shale gas, an unconventional source of natural gas is also gaining in demand. It is forecasted to meet 29 percent of US energy demand by 2020. (Channel News Asia, 2011)

Renewable energy could take much a larger pie of the world energy mix in the future too. At present, it accounts for 3 to 4 percent of the global energy mix. This is likely to increase to 7 percent by 2020 and 14 percent by 2030 and a further increase by 2050.

Looking ahead into the year 2050, the NSR could become the new sea highway between Europe and Asia, given that the Arctic ice caps and glaciers are melting at an exceptional rate. The year 2011 will be seen as the take off year for commercial shipping along the NSR. (Thomas, 2010) Rosatomflot, Russia’s nuclear ice-breaker fleet has got up to 15 orders consisting of cargo vessels and bulk carriers for assistance this year. (BarentsObserver, 2010)

Alternative modes of transportation like railways and pipelines could be further developed and improved to handle the forecasted increase of cargo in 10 years time. Cargo could be transported all over the world using railways by adopting the Trans-Siberian Railway concept while pipelines could be used for oil and gas. However, in-depth research and extensive cost calculations have to be done in order to make a final conclusion on how these changes would impact sea transportation in 2050.

It is important not to forget how these changes could impact Singapore too. Although the NSR is said to provide a much shorter route, the start and end ports should be taken into consideration. Sailing from Yokohama to Rotterdam via the NSR totals a distance of 7,825 nautical miles while transiting through the traditional Suez Canal takes a total distance of 11,212 nautical miles. This shows that the NSR is not beneficial to all ports situated in the Far East or Europe region and further research and calculation should be done before a ship owner decides on the exact route to be travelled by the vessel.

Taking a look into Singapore future energy mix, plans to become a LNG trading hub and a renewable energy powerhouse are in sight. With efforts to tap into cleaner energy, Singapore could achieve her ambition to become a cleaner and greener nation by 2050.
Singapore maritime industry could also tap on new business opportunities in view of the opening of the NSR. Companies like PSA International could consider venturing into Russia to take advantage of the future increase in cargo volume which is predicted to increase by three times. (Lynn, 2010) Moreover, the current state of infrastructure of the ports along the NSR is said to be undeveloped. When a port of international standard becomes a reality, the option of building an oil terminal or oil refinery upon the port could be possible. Singapore being one of the top bunkering ports in the world could consider setting up a trading hub in that region too. If plans for a port are not possible, PSA Singapore could also look into providing consultancy services such as port building, port management and port planning to port operators along the NSR. PSA is constantly innovative in automation and the use of intelligent systems with applications such as CITOS® and PORTNET®. Thus, other port operators might be interested in learning from PSA.

Having a tripartite collaboration with universities from Russia, Singapore and Norway could improve relations as well as the exchange of knowledge and experience. Students from these universities can embark on cross internship programmes with local companies from these respective countries to gain insightful international working experience. This will enhance deeper cultural and economic understanding. In view of the opening of the NSR, the network formed from the result of these joint programs between the universities can lead to business, projects and research opportunities in the future.

With Singapore thriving to become the International Maritime Centre, it is important for her to be actively involved in the legal side of the Maritime sector as well. The recent launch of the SSF has shown that Singapore is gearing ahead and is showing growth potential to become an Arbitration Hub for the Asia region. As Singapore is a neutral nation, she could be seen as the preferred jurisdiction to legal related issues arising from territorial claims made by the five Arctic coastal states.

Lastly, this report proposes a few propositions which Singapore could develop upon although the feasibility of these propositions depends on the government and private organizations on whether they view the Northern Region as a market which could be venture into. Singapore aims to become an International Maritime Centre and thus, it is important that she views every market as an opportunity and not as a threat.

The question to be asked if the Arctic will be ice-free by the year 2050 is no longer the matter of “if” but rather “when”. The year 2050 could be too short a time for the Arctic routes to be
completely ice-free all year round, however it is never too early to prepare for such a phenomenon.
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APPENDIX
School of Civil and Environmental Engineering/Maritime Studies

**Background**

The Arctic is a region located at the Northern Hemisphere, accounting for about 6% of the Earth’s total surface area. The Arctic which is covered in ice caps and glaciers was once impenetrable by humans. At present, ships are able to pass through this region for a period of three months. Predictions report an ice-free Arctic by 2050 due to accelerating rate of melting ice caps and glaciers, resulting from global warming. A new commercial shipping route along the Siberian coast might become a reality.

The NSR serves as an alternative route from the traditional routes via the Suez Canal. Sailing through the Arctic Ocean via the NSR could save up to 40% of the sailing distance. This could result in lower bunker consumption and hence lower greenhouse emissions.

Although global warming and climate change have been a growing concern, they have ironically paved the way to the accessibility of massive oil and gas deposits lying beneath the Arctic Ocean. It is estimated that the total amount of these resources account for 12% of the world’s reserves. This is likely to attract future explorations in the Arctic region, thus strengthening the position of the NSR as an international commercial route.

The focus of this project is to look into the opportunities and threats that Singapore will face as a Maritime Hub in view of the opening of the NSR.

**Interview Questions for Joshua Ho**

1. You wrote a commentary in 2009 on the NSR - A new transit passage between Europe and Asia. Why is there a particular interest in the Arctic?
2. According to the same commentary, you mentioned an ice-free passage as early as 2013. Do you think it is still achievable?
3. Would you like to share your latest research with regards to the Arctic region?
4. What is your take on global warming by 2050? Do you think the Arctic would be ice-free by then?
5. In your opinion, how will global warming affect the trade routes along the NSR? Will this have an impact on the type of ship size used?
6. How will Singapore and the rest of the world be affected with the opening of the NSR?
7. According to Transparency International, Russia is one of the most corrupted nations. In today’s context, has corruption in Russia deterred the use of the NSR? How will this issue affect the use of the NSR in the future?
8. In your opinion, what are the security challenges faced in NSR?
9. In your opinion, how can Singapore and Russia work together to enhance security along the NSR?
School of Civil and Environmental Engineering/Maritime Studies

**Background**

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**Interview Questions for Soh Woei Liang**

1. In your opinion, do you perceive the NSR as a popular shipping route in 2050?
2. In your opinion, do you think the opening of the NSR will have an impact on the number of vessels calling at Singapore for the Europe-Far East trade route?
School of Civil and Environmental Engineering/Maritime Studies

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**Interview Questions for Teh Kong Leong**

1. In your opinion, do you perceive the NSR as a popular shipping route in 2050?
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Interview Questions for DNV

1. Do you see a day when it is mandatory for all commercial vessels to run on renewable energy?
2. From your website, we understand that DNV has developed Triality concept VLCC. In your opinion, how is this concept extended to an Arctic going vessel?
3. What are some of the new technology solutions and ship designs developed for the Arctic?
4. What are the risks involved in ships operating in the Arctic region?
5. From your website, it mentions the carbon capture and storage (CCS) approach to reduce carbon dioxide and a de-carbonised energy future. Can you tell us more about it?
6. Can you share with us some of the green technologies which can minimize the impacts of ballast water and gaseous emissions?
7. Predictions report an ice-free arctic by 2050. What are the opportunities and threats that Singapore might face?
Background

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Interview Questions for Beluga

1. In 2009, two German heavy-life vessels, MV Beluga Fraternity and MV Beluga Foresight, made the first-ever commercial voyage through the NSR. Why was there a special interest in the NSR?
2. Can you share with us MV Beluga Fraternity’s and MV Beluga Foresight’s experience in transiting through the NSR?
3. What were some of the obstacles Beluga faced during the voyage through the NSR?
4. From your understanding, can you share with us the port conditions and infrastructure along the Siberian coast in Russia?
5. In your opinion, do you perceive the NSR as a popular international shipping route by 2050?
Background

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Interview Questions for PSA

1. How does PSA position itself to compete in the global market today?
2. If PSA were given an opportunity to expand into Northern Europe, where would you strategically locate your port?
3. In your opinion, what factors would attract a global port operator to expand its port operations into Russia?
4. Has PSA thought of venturing into the Arctic region in the near future?
5. In your opinion, do you perceive the NSR as a popular international shipping route in 2050?
6. Predictions report an ice-free Arctic by 2050. What are the opportunities and threats that PSA might face?
Background

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Interview Questions for Liu Miao Jia

1. Can you tell us more about the transport and infrastructure conditions along the Siberian coast?
2. Can you share with us some of the challenges you faced while gathering data about Russia?
3. Will the development of pipelines in Russia have an impact on tankers plying the NSR?
4. What growth potential do you see in Russia’s shipping market?
5. In your opinion, how will the world’s trade pattern change with the opening of the NSR?

The following questions are made with reference to your research paper on “The economic potential of using Northern Sea Route (NSR) as an alternative route between Asia and Europe” in 2007.

1. You chose the ports of Rotterdam and Yokohama for your research paper. What was the reason behind this selection? Have you considered other Asian ports?
2. With the current developments in Russia, do you see a day that the ice breaking fees will be reduced by 100%?
3. What developments/improvements do you think need to be in place for the NSR to gain popularity as an international route? Do you perceive the NSR to be a popular shipping route by 2050?
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Interview Questions for IE Singapore

1. What are the conditions required for a local company to invest in Russia?
2. What challenges might local companies face if they were to venture into the Russian market?
3. How does IE help local companies venture into the Russian markets?
4. How well was the response from local investors towards the Russia-Singapore Business Forum?
5. How many maritime companies have expressed interest and/or approached IE for assistance to invest in Russia?
6. In your opinion, do you think Singapore will sign a FTA with Russia within the next 5 years?
7. Predictions report an ice-free Arctic by 2050. What are the opportunities and threats that Singapore might face?
Background

Climate change is caused by global warming resulting from the release of greenhouse gases into the Earth’s atmosphere. This slows down the rate of heat escaping from the atmosphere and acts like a warm air-blanket surrounding the Earth.

Climate models used by the Intergovernmental Panel on Climate Change (IPCC) have predicted a three to four degrees rise in global temperature, resulting in a decreasing rate of three to five percent per decade of total ice extent and rising sea levels.

In addition, predictions report an ice-free Arctic by 2050 due to accelerating rate of melting ice caps and glaciers. Hence vessels sailing from Far East to Europe via the Arctic sea routes could save up to 40% of the sailing distance as compared to the traditional Suez Canal. This could result in lower bunker consumption and thus lower greenhouse emissions. Therefore, it is evident that global warming will have a strong impact on ship transportation along the Arctic sea routes.

The focus of this project is to look into the opportunities and threats that Singapore will face as a Maritime Hub in view of the impacts of climate change.

Interview Questions for MPA

1. How does MPA enhance local maritime companies’ competitiveness on an international scale?
2. In your opinion, how will the rising concerns over Climate Change and Global Warming affect Singapore as a Maritime Hub?
3. How do you picture Singapore’s Maritime Industry to be like in 2050?
4. We understand that MPA has expressed interest in a project between NTU and Norway (BI Norwegian School of Management) – Climate Change and Singapore. What are the reasons that sparked the interest in this project?
5. Predictions report an ice-free Arctic by 2050. What are the opportunities and threats that Singapore might face?
6. What is your view on the future development of the Arctic?
Background

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Interview Questions for Earth Observatory of Singapore

1. With the current rate of Arctic ice melt, when do you expect to see an ice-free Arctic?
2. What are the impacts of Global Warming on the Arctic region?
3. What are the impacts of Global Warming on Singapore in terms of rainfall, temperature and etc?
4. Can you share with us some statistics on the amount of ice melt in the Arctic region presently and in 2050?
5. Predictions report an ice-free arctic by 2050. What are the opportunities and threats that Singapore might face?
Background

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Interview Questions for APL

1. What are the reasons behind APL’s decision to expand into the Russian market?
2. From your experience, what are the challenges faced when breaking into Russia’s maritime market?
3. According to Transparency International, Russia is one of the most corrupted nations. To what extent has corruption impeded NOL Group’s advancement into Russia?
4. Beluga Shipping has successfully transited the NSR in 2009. In your opinion, do you perceive the NSR as a popular international shipping route in the container industry by 2050?
5. What is your view on APL using the NSR to transit from Far East to Europe the day when the Arctic is ice-free?
6. How do you see APL being more involved in the Arctic in the near future?
7. From a liner’s perspective, do you see liner shipping increasing its presence in the Arctic region? What are the factors which drive liner companies to expand into the Northern trade?
8. Predictions report an ice-free Arctic by 2050. What are the opportunities and threats that APL might face?
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Interview Questions for Lukoil

1. What were the key reasons behind the collaboration with Keppel?
2. What growth potential do you see in Russia’s shipping market?
3. Does Lukoil have any key projects in the Arctic region?
4. Statistics have shown that the demand for natural gas is on the rise. Do you see a day when the demand for natural gas will surpass the demand for oil?
5. Looking into the future, how do you see Lukoil’s business developing in the Arctic region?
6. Predictions report an ice-free Arctic by 2050. What are the opportunities and threats that Lukoil might face?
School of Civil and Environmental Engineering/Maritime Studies

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**Interview Questions for Portek**

1. Can you share with us more about the operations of your subsidiary, Europort?
2. What were the reasons for Europort’s collaboration with Russian Armley Investments Limited?
3. Why did Portek choose to develop and operate a container and multi-purpose terminal in Kaliningrad, Russia?
4. From your experience, what was the greatest difficulty faced when breaking into Russia’s maritime market?
5. Did the Russian-Singapore Business Forum (RSBF) serve as a helpful platform for your company in the collaboration with Russian Armley Investments Limited?
6. Does Portek see Russia as the next up and coming Maritime Hub?
7. Does Portek plan to have further investments in Russia?
8. Predictions report an ice-free arctic by 2050. What are the opportunities and threats that Portek might face?
Background

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