CHALMERS

The development of the Natural gas market and the LNG market

Prediction for the future development of the natural gas market and the LNG market based on the analyses of data within a time period of 10 years.

Bachelor thesis for Master Mariner Program

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover:
Picture of MOL FSRU Challenger, 06.2020, by Sergey Livanov

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PREFACE

The global Liquefied natural gas (LNG) trade has opened new opportunities within the shipping market through the expanding global LNG carrier fleet. As students of the Department of Mechanics and Maritime Sciences the Chalmers University of Technology, studying to become second officers we wanted more comprehensive knowledge within this field, in order to understand how the market will develop. This specific shipping industry is especially relevant for us, since the two of us choose to specialize in tankers for our fourth and final year of our education.

This bachelor thesis represents the comparison of statistical data from ten years ago and present time, in order to analyze the development of the LNG market and to have availability to make predictions for further development based on the expansion curve of the last decade.

We would like to give a big thank you to Jan Skoog as our supervisor in researching and writing this bachelor thesis. We also want to thank Olle Lindmark and Monica Lundh for their help with writing this thesis and Sergey Livanov for providing the cover picture.

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SAMMANDRAG (in Swedish)

Den globala produktionen och konsumtionen av existerande naturgas har utökats sedan 2009, samtidigt som nya källor upptäcks och utvinns för att tillfredsställa efterfrågan från marknaden. Resultatet av det är att den globala handeln av naturgas har samt fortsätter att växa

LNG marknaden har under de senaste årtiondena har växt, sedan 2009 har marknaden växt med 94%. Naturgas har blivit en mycket attraktiv energikälla på grund av miljöfördelarna samt att det anses vara mycket prisvärt. Det har ett relativt lågt utsläpp och anses var mer miljövänligt än många traditionella typer av fossila bränslen, som till exempel olja och kol. På grund av detta är det troligt att den globala konsumtionen kommer att öka, dock möjligtvis inte i samma utsträckning som den har gjort fram tills nu. Som en påföljd detta av är det troligt att handeln av naturgas mellan länder kommer att öka. I denna rapport har statistik från 2009 och 2019 analyserats för att kunna jämföra läget av naturgasmarknaden för att presentera tillväxten och de stora förändringarna marknaden har genomgått. Vidare presenterar vi även förutsägelser från experter inom energisektorn för de kommande 20 åren, detta är för att kunna få en bättre uppfattning över hur marknaden kommer utvecklas och anledningarna till att det är mycket troligt att det kommer fortsätta utökas.

Nyckelord: LNG, naturgas, marknaden, förutsägelser, utveckling, bränsle, energikälla, konsumtion, produktion, handel.

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ABSTRACT

The global production and consumption of natural gas have expanded since 2009 and at the same time new deposits of natural gas are still being found. The result of this growth is that the global trade of natural gas has been gowning as well to satisfy the consumer demand for the energy source.
The LNG market has been growing during the last decades and has expanded by 94% since 2009, and natural gas has become a very attractive energy source due to environmental benefits and the affordable price. Natural gas has a relatively low emission and is considered more environmentally friendly compared to many traditional types of fossil fuels, such as heavy fuel oil and coal. Due to these benefits it is likely that the global natural gas consumption will continue to grow over the next 20 years. However perhaps not to the same extent as the previous decade. As a consequent of this, it is also likely that the global trade will increase. In this report, statistics regarding the natural gas market from 2009 has been analyzed in order to compare to statistics from 2019. This is to present the growth and to show the major changes that the market has grown through. Predictions made by experts within the energy sector regarding the next 20 years are presented. This is in order to better understand how the Natural gas market will develop, as well as to explain the factors contributing to the predicted future growth of the market.

Keyword: LNG, natural gas, market, prediction, development, fuel, consumption, production, trade.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND TERMINOLOGY

BCE	Before the Common Era
Bcm	Billion cubic meters
BP	Is a company, formerly The British Petroleum Company
CBM	Coalbed methane
CO2	Carbon dioxide
ECA	Emission Control Area
GHG	Greenhouse Gas
GIIGNL	International Group of Liquefied Natural Gas Importers
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MD	MilliDarcy, the unit of measurement of permeability
MGO	Marine Diesel Oil
NGL	Natural Gas Liquids
NOx	Nitrous Oxides
ODS	Ozone Depleting Substances
SECA	Sulphur Emission Control Area
SOx	Sulphur oxides
Tcm	Trillion cubic meters

1. INTRODUCTION

Growing demand for alternative sources of energy makes natural gas one of the fastest growing markets in the energy sector in the modern economy. Liquefied natural gas (LNG) is more frequently used as fuel for transportations and as cargo to supply global markets with alternative low Sulphur emitting energy sources. Low emissions and affordable prices make natural gas a very competitive energy source compared to crude oil and other oil products.

During the last decade an increase in newly produced vessels and LNG terminals around the globe has been seen (Le Fevre, 2018). Predictions for expansion can be made for the next decades by monitoring new projects that are planned and are already in progress.

Previous research (Sandström and Waahler, 2012) shows the situation of the LNG market with its predictions for the year the research was written. There has been significant growth of the global LNG fleet, it has increase from 360 LNG tankers in 2010 to 601 tankers in 2019 (Statista, 2020). This is directly connected to the increased consumption and trade of natural gas worldwide.

The increase of LNG as a fuel is partly a consequence of a new International Maritime Organization (IMO) regulation. This regulation demands that emissions from vessels do not exceed 0.1% of Sulphur in the Sulphur Emission Control Area (SECA) and Emission Control Area (ECA) regions, and 0.5% in the rest of the world except for inland waterway traffic. This makes shipping companies look at economically sustainable solutions to reduce exhaust emission (Le Fevre, 2018). LNG is an attractive option due to low Sulphur emission, secure technology for usage as fuel, the vessel can be used for 30 years and it is cost efficient. (Wang, Rutherford and Desai, 2014 August).

This bachelor thesis is partially based on a suggestion in an earlier study by Sandström.D and Waahler.O (2012), to analyze the global LNG market out of the present perspective. Though due to the fact that their study was made in 2012 and our research will not only look at the market today but also compare it to the market 2009 and look at the current predictions for the development.

1.1 Background

Natural gas has become a big part of the world's energy sustainability and is expanding to become one of the main energy sources in the near future. These facts make it important to research and make predictions regarding expansion within the industry and the market for the near future. Moreover, implementation of natural gas as an energy source and is affecting the economical and climate situation globally. Information gathered in this report may be useful for further studies and monitoring the market development and climate changes.

1.2 Aim of the study

The purpose of this project is to evaluate the past developments and make new ones concerning the new data and the changes in world's economics, technical development and environmental situation. This work is based on statistics regarding the production, consumption and the global trade of natural gas made by different major companies and organizations within the energy sector. The study will also focus on past and present studies in the energy sector in order to compare the development of the market with the purpose to understand how and why the market has grown so rapidly to its current state. This is also important to take into consideration regarding the current predictions to get an accurate idea of how the market will develop.

1.3 Research questions

How did the market look 2009?
How did the market look 2019?
How and why has the market developed?
What are the predictions for the Natural gas market until 2040?

1.4 Delimitations

This study will look at the past, present and predictions for the global commercial natural gas market and emission control initiatives within the period from 2005 to 2040. The information used in this research will mainly be focused on the pressure to implement alternative types of energy sources due to environmental and economic concerns in the present day. Factors like crisis, war, sanctions, epidemics will not be analyzed.

2 THEORY

The theory chapter includes description of natural gas and the history, extraction, refitment, transportation and history behind it. It will also include information about the market and environmental initiatives.

2.1 What is Natural Gas

Natural gas is a fossil source of energy that is found in massive deposits, deep below the earth's surface. Usually, these deposits are found deep beneath the bottom of the ocean or deep in the earth's crust. The deposits were formed millions of years ago from remains of plants and animals because of high temperature and high pressure (Speight, 2018).

Natural gas mainly consists of methane CH4 (85-95%), ethane (10-15%) and other gases such as butane, propane, and nitrogen. A full list of content can be seen in table 1. Mokhatab and Poe (2012) describes the physical characteristics as: "*Natural gas is colorless, odorless, tasteless, shapeless, and is lighter than the air*" (p. 6).

Table 1
Table of composition of natural gas

Constituent	Formula	% v/v
Methane	CH_4	>85
Ethane	C_2H_6	3–8
Propane	C_3H_8	1–5
n-Butane	C_4H_{10}	1–2
iso-Butane	C_4H_{10}	<0.3
n-Pentane	C_5H_{12}	1–5
iso-Pentane	C_5H_{12}	<0.4
Hexane, heptane, octane[a]	C_nH_{2n+2}	<2
Carbon dioxide	CO_2	1–2
Hydrogen sulfide	H_2S	1–2
Oxygen	O_2	<0.1
Nitrogen	N_2	1–5
Helium	He	<0.5

Note: Table represents percentage ratio of natural gas composites.
Source: J.D. Speight, 2019, "Natural Gas: A basic handbook"

There are different types of gas when it comes to how it is produced and where it is taken from. It is mainly divided in two big categories: conventional and unconventional.

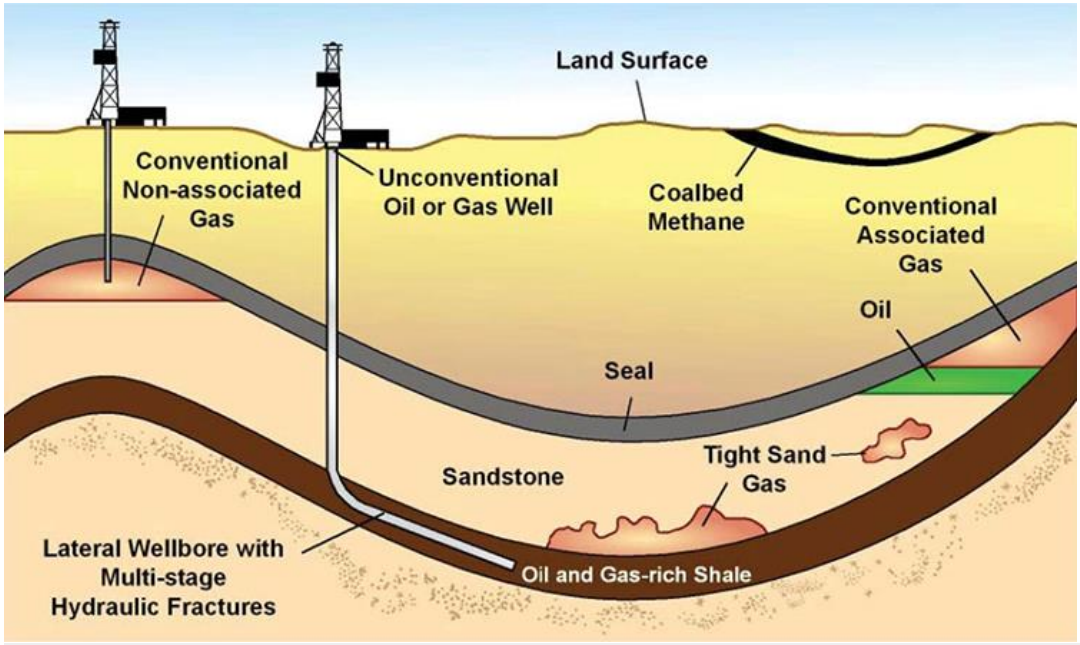
Liquefaction of Natural Gas
Liquefaction of natural gas is a cryogenic process made in cascade cycles until the required parameters are reached and gas is turned into a liquid. To reach the extremely cold temperatures of -162°C that is required to produce LNG, the gas is put through the processing of going through refrigerant compressors in multiple refrigeration cycles. When the gas is liquefied its volume shrinks by a factor of 600 and is suitable for transportation (Mak et al., 2014).

2.1.1 Conventional gas

Cleveland and Morris (2009) describes conventional gas as "Natural gas obtained by the traditional method of extraction from deep-lying geologic formations, as opposed to that obtained from other sources, for example, coal-bed methane." (p. 131). Explained a different way; conventional gas is natural occurring hydrocarbon from deep-lying geologic formations that has good flow availability through the substance it is located in (sand, rock and similar) as is illustrated in figure 1, and can be extracted by conventional (traditional) recovery methods, such as well drilling. Conventional gas is most often found in reservoirs with permeability greater than 1 milliDarcy (>1MD) (Speight, 2018).

Associated gas
Associated gas is found together with oil reservoirs. It can occur as free gas (gas cap) in a petroleum reservoir or as a gas solution in petroleum. Gas found as solution in petroleum is also called dissolved gas.
Production of crude oil is always combined with production of associated gas as it comes as a byproduct. (Speight, 2018)

Figure 1
Gas and oil formations



Note. Figure describes different gas and oil formations from a geological perspective.
Source: U.S. Energy Information Administration, adapted from United States Geological Survey factsheet 0113-01 (public domain)

2.1.2 Unconventional gas

Unconventional gas is recovered from geological formations such as rock, shale and oilsands with very low permeability (less than 1MD). Due to low permeability of geological formations, it is difficult and, in most cases, impossible to extract that type of gas with conventional methods. Recent newly developed technologies such as hydraulic fracturing (see chapter 2.2.1) has led to significant increase of that type of production (McGlade et al., 2013).

Unconventional natural gas can be divided into several different categories such as: methane hydrates, biogas, coalbed methane, flue gas, gas in depressurized zones, gas in tight formations, landfill gas, manufactured gas, refinery gas, shale gas, synthesis gas (Speight, 2018).

Shale gas
Shale gas or tight gas is found in small bubble-like pores inside of the tight underground layers with low permeability sedimentary rock such as shale. Shale gas and tight gas are usually used as the same type of gas within different descriptions, but there is some difference between them. As can be seen in figure 2, they are located in reserves of different permeability. Shale gas is found in the rocks, while tight gas is found in low-porosity silt or sand that creates a tight-fitting environment for it (Speight, 2016).

Figure 2
Reservoir classification by permeability

Note. Representation of the differences in permeability of shale reservoirs, tight reservoirs, and conventional reservoirs.
Source: Livanov, J (2021) based on J.D. Speight, 2019, “Natural Gas: A basic handbook”

Coalbed Methane
Coalbed methane (CBM) is natural gas stored within coal deposits. It has been known by mine workers for at least 150 years for its high flammability before it was developed as CBM (Speight, 2016).

CBM is extracted by horizontal wells or by using hydraulic fracturing. Before extracting natural gas from CBM reservoirs it must be considered that some of them are also a source of drinking water and in those cases restrictions on hydraulic fracturing operations may be applied (Speight, 2016).

CBM is formed as part of geological formation of coal and is present in different quantities within all coal. This type of gas is exceptionally pure and can be transported to consumers with no or little treatment. Extracted CBM in its composition has over 90% methane (Speight, 2016).

2.1.3 History of LNG

The first description of use of natural gas was recorded in Iran sometime between 6000 and 2000 BCE (before the common era). It was used for religious purposes such as a sacramental light. Later use of natural gas that is known was in China where the first well was dug to the depth of 150 meters with help of bamboo poles. After that period there was no historical evidence of use of natural gas until the 17th century when it was discovered in England in 1659. Britain was also the first country to commercialize natural gas. In 1785 gas was extracted from coal and it was used in households and light streetlights. Later in 1829 natural gas was distributed commercially in America, New York state, Fredonia city. It was used for lightning and cooking (Speight, 2018). Some of the major events up to 1885 are listed in table 2.

The slow development of use of natural gas was due to the lack of technology for transportation. Although in 1890 leak proof pipes were invented so that the gas could be transported for longer distances to the customers without any significant losses (Speight, 2018).

In 1920, technology for transportation of LNG by ship was patented by Godfrey L. Cabot, but the technology was not used for many years. Not until 1959, when the first LNG vessel named "The Methane Pioneer" made its first journey with LNG cargo onboard from Lake Charles in US to Canvey Island in Great Britain (Gałczyński, et al., 2017).

Due to technological advances with the development of storage systems and pipelines there was a rapid gas demand growth after The World War II. The major increase in demand of natural gas occurred between 1965 and 1975 when the consumption increased by 83%. Since then, the average annual growth rate of primary energy demand has been 1.92% (Gałczyński, et al., 2017).

Table 2
Timeline of development of natural gas

1620	French missionaries recorded that Indians ignited gases near Lake Erie
1785	Natural gas is introduced for home and street lightning
1803	Gas lightning system patented in London by Frederick Winsor
1812	First gas company founded in London
1815	Meeting for households, invented in 1815 by Samuel Clegg
1816	First US gas company (using manufactured gas) founded in Baltimore
1817	First Natural gas from wellhead used in Fredonia, NY for house lightning
1840	Fifty or more US cities were burning public utility gas
1850	Thomas Edison postulated replacing gas lightning by electric lightning
1859	Carl Auer von Welsbach in Germany developed a practical gas mantle
1885	Depleted reservoirs are used for the first time to store gas

Note. Table shows historical timeline, that shows major events in development of natural gas.
Source: Own table based on J.D. Speight,2018, "Natural Gas: A basic handbook"

2.2 The infrastructure behind the LNG Global trade

2.2.1 The extraction

Natural gas is extracted from the underground reservoirs through wells. Well construction is similar to crude oil wells, with tubing, casing and wellhead control on the top. Some gas formations lie deep under the surface, for example the deepest well Sakhalin O-14 is 1005.84 meters below the surface (statista.se).

Extracting crude oil or gas from such deep formations is impossible using only one pipe and that is when casing is used. Casing is a method of extending the length of the pipe under the surface. Pipes are telescoped inside each other with cement on the outer layer protecting it from the pressure (Speight, 2018).

Tubing is used when the pressure in the well is decreasing or is insufficient. It is used to increase or to maintain a constant flow by inserting a pipe of a much smaller diameter into the well. Using that method leads to a higher pressure in the small diameter pipe and as a result a higher flow rate (Speight, 2018).

Before the start of drilling a geological survey must be made to define the approximate amount of gas in the reservoir. Once a gas formation has been located a group of specialists is sent to the site to determine the exact place of drilling. There are many factors that should be considered. Not only economical, but also the nature of geological formation to be drilled and depth of the future well (Speight, 2018).

Once the extraction starts the pressure in the reservoir will decrease, and that will lead to a decrease in production over time. Big gas formations can maintain the same amount of production for years, as the pressure will drop at a very slow rate and the natural flow of gas will be constant. When the pressure drops significantly mechanical pumps are used to bring product to the surface (Speight, 2018).

Some wells are drilled in the places where gas is stored in low permeability reservoirs. In those cases, gas is extracted through the large diameter wells with vertical sections to extract more gas. Production can be increased by hydraulic fracturing the tight formation with the purpose to release the gas that is stored in it (Cheremisinoff and Davletshin, 2015).

Hydraulic fracturing is a technique used to extract natural gas from under the earth surface. Vertical wells are drilled hundreds or thousands of meters to reach gas formations. Once the layer has been reached, drilling operation is then angled horizontally. A large amount of water, fracking fluid, chemicals, and sand are injected with the purpose to fracture the rock and shale, to release the gas stored in its structure (Cheremisinoff and Davletshin, 2015).

2.2.2 The refinement

Natural gas that is brought up to the surface is not the same gas that is used in production or heating. Natural gas used by consumers mainly consists of methane (>95%), while the gas from the well has about 65% of methane. Before the gas reaches the consumers, it must be refined, and certain parts of its composition must be removed. Gas from the wells is transported to the nearest refinery where it is processed in four main stages: oil and composite removal, water removal, separation of natural gas liquids (NGLs), hydrogen sulfide removal and carbon dioxide removal (Speight, 2019).

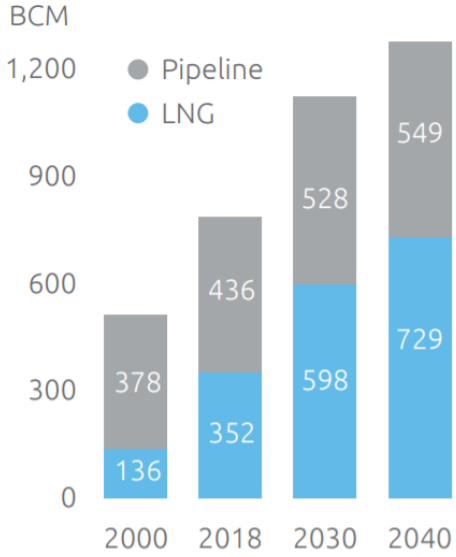
2.3 The transportation of Natural Gas

Natural gas transportation is divided in two different sectors. It is transported by pipelines or by LNG vessels. These two categories are divided almost equally, where pipelines counted for 50.7% in the year 2019 with a decrease of 1.7% the same year and LNG vessels transport 49.3% 2019 with an increase of 12.7% (BP,2020). The division between the two transportation types is presented in figure 3.

LNG carrier vessels are built in different sizes with varying capacity from 1000 m^3 to 265000 m^3 in order to be suitable for different needs and possibilities to operate in different areas (GIIGNL, 2019). In 2019 there were a total of 601 LNG tankers in the global fleet (Statista, 2020).

Pipeline transportation is limited to the geographical regions in which the gas is produced at, and the nearby countries where it could be transported by pipelines. Although some of the pipelines can reach 8700 km (West-East pipeline, China) they are not as flexible as deliveries by LNG vessels (Offshore Technology, 2020).

Figure 3
Natural gas trade by pipeline and LNG



Note. The table shows the amount in bcm transported by pipeline and LNG in 2000 and 2018, as well as the predictions for 2030 and 2040.
Source: BloombergNEF 2020. International Gas Union. 2020. Global Gas Report 2020.

2.4 Market theory

The growing demand on energy resources has caused a need in developing the new international market for natural gas. Hydrocarbons have a great importance in global consumption of primary energy and counted for 86.3% of the total global energy consumption in 2014. Developing a new LNG market was dictated by the demand, so that more countries that did not have the possibility to produce natural gas could import it (Gałczyński, et al., 2017).

A majority of countries are directly dependent on import of energy resources, so that their economies could function normally. LNG shipping made it possible to fulfill the needs of these countries and make deliveries safe. The five countries with the biggest resources hold more than 63% of global resources of natural gas. The top ten of these countries hold 79%, they are listed in table 3. LNG shipping made it possible to transport natural gas by seas and not only by pipelines as it was done for decades before (Gałczyński, et al., 2017).

Table 3
Top ten countries by proven gas reserve

Nation	**2009**	**2019**
Russia	34 bcm	38 bcm
Iran	28 bcm	32 bcm
Qatar	26.2 bcm	24.7 bcm
Turkmenistan	8.2 bcm	19.6 bcm
United States	7.4 bcm	12.9 bcm
Venezuela	5.6 bcm	6.3 bcm
Saudi Arabia	7.4 bcm	6 bcm
United Arab Emirates	5.9bcm	5.9 bcm
Nigeria	5 bcm	5.4 bcm
Algeria	4.3 bcm	4.3 bcm

Note. List of countries with largest proven reserve in 2009 and 2019, in descending order. Source: Own table based on BP, 2020, Static Review of World Energy 2020 (69th Edition).

LNG is mainly used for transportation and producing electrical power for the productions industries and heating. There are not only economic reasons for the growth of LNG consumption, but ecological as well. According to the Paris Agreement (2015) the global emissions of carbon dioxide (CO2) were calculated to rise by close to 30% between 2005 and 2030, a new solution had to be found to replace the use of traditional energy sources such as crude oil. One example is that natural gas has 90% lower emissions of particulates and 30% lower CO2 emissions compared to crude oil (Speight, 2018). Another example of this can be seen in the marine fuel market, because companies have begun to order LNG fuel vessel. LNG seems to be a good solution for the traditional marine fuel heavy fuel oil (HFO) as it has not only lower greenhouse gas (GHG) emission but also NOx (nitrogen oxides) and SOx (sulfur oxides) emissions are lower (Le Fevre, 2018). A compression of emission from HFO, marine diesel oil (MDO) and LNG can be seen in table 4.

Table 4
Emission factors for marine fuels (g/g of fuel)

Emission	HFO	MDO	LNG
SO_x*	0.049	0.003	trace
CO_2	3.114	3.206	2.750
CH_4	trace	trace	0.051
NO_x	0.093	0.087	0.008
PM	0.007	0.001	trace

Source: IMO (2014)

Note. The table list the gram of emission per grams of fuel form HFO, MDO and LNG
Source: Le Fevre, C. 2018. A review of demand prospects for LNG as a marine fuel

2.5 Environmental regulations

Use of fossil fuels is deemed to be harmful for the environment and must be regulated in order to stop global warming. Scientists have been concerned about this problem for many decades now, but there were no sufficient reactions in the world of industry and politics. When the changes in climate became visible and unavoidable it opened a field for international discussions and the need to take action was determined. Major international regulations were applied.

One of them is the Paris Agreement that was signed in 2015 by 195 countries that produce more than 55% of all greenhouse gas emissions. The Paris Agreement (2015) has the purpose for countries to take action in holding the global average temperature rise to below 2.0°C of pre-industrial level and make a best effort to hold it to 1.5°C below pre-industrial level.

Regulations concerning maritime industry were applied by IMO in the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI first in 1997 with entry in force from 19 May 2005. Regulation concerns reducing SOx and NOx emissions and prohibits intentional emissions of ozone depleting substances (ODS) (IMO, 2020).

2.6 Previous research

In research published in 2012 “En kartläggning av den globala handeln med Liquefied Natural Gas, LNG” written by Sandström and Waahler conclusions that the LNG market will expand in the near future were made. Market expansion rate was deemed to reduce as it has had a growth of almost 33% between the years 2010 and 2012, which is a high rate and was considered the peak of growth. Liquefication of natural gas for transportation was about 10% of total amount of production and was predicted to expand to a certain degree.

3 METHODS

The aim of this study was to look through the development of the natural gas market and emission control initiatives from 2005 to 2020 and look at predictions made by experts until 2040. The statistics to evaluate the situation today is from the year 2019 because the statistics from 2020 was not yet released. The year 2009 was chosen to see the growth or decline over a time period of 10 years.

3.1 Research method: Documentary research

A documentary research is where the information in a report is based on previous studies or existing literature, not on collecting information through surveys or practical experiments. The facts presented in documentary research can be from written texts, digital publications, and visual sources. This includes government documentations and official statistics, newspapers and magazines, records of meetings, letters and memos, diaries, and webpages and the internet (Denscombe, 2014).

In order to answer the questions formulated in this report, previous reports, research and publications regarding natural gas and the LNG market found in Chalmers University of Technology's own library was used. In addition to this Google search engine is one of the internet sources that was mainly used to find official websites of main entrepreneurs and organizations in this field of industry. Statistics on the natural gas reserves, productions, consumptions, imports, exports, and predictions from credible sources was collected in order to answer the questions.

There is also information collected from previous reports written by experts in this field regarding this subject. In order to gather the most reliable information, official websites of members in this industry and other universities that made that type of research are preferred. When deciding which sources will be used, they will have to be written or published by trusted individuals or institutions.

3.2 Quantitative and Qualitative methods

Quantitative data is expressed in the form of numbers and is useful for a researcher to gather information for further evaluation in their studies. Quantitative method is used to analyze and compare numbers. It gives availability of selecting specific information in order to find certain tendencies that could be used for further studies. Qualitative data is expressed in the information that is given in the text and is needed for understanding the reason for why certain changes have been made (Denscombe, 2014).

Documentary research can include both quantitative and qualitative research methods.

Quantitative documentary analysis involves the examination of relevant documents for the numerical data they contain relating to the topic of interest (Tight, 2019).

Qualitative documentary analysis involves the examinations of relevant documents for the informational data using two or more sources (Tight, 2019).

Documentary research complies with this study as its purpose is to gather quantitative information from annual rapports and to analyze the major changes in the different years. Qualitative information is used to determine the reasons as to why these changes have occurred.

3.3 Information evaluation

Table 5
Methods and reliability of different sources

Organization/Author	Source/Research	Type of Method		Reliability
BP	Statistical Review of World Energy 2020	Quantitative		High
Cheremisinoff, N., Davletshin, A	Hydraulic Fracturing Operations: Handbook of Environmental Management Practices		Qualitative	Very High
Cleveland, C, J., Morris, C	Dictionary of Energy		Qualitative	Very High
Denscombe, M	The Good Research Guide (Fifth Edition)		Qualitative	Very High
Gałczyński, M., Ruszel, M., Turowski, P., Zajdler, R., Zawisza, A	Global LNG Market		Qualitative	Very High
Holmes, C., Rogers, D	THE IMPACT OF THE GLOBAL ECONOMIC CRISIS ON GLOBAL LNG TRADE AND SPOT LNG PRICES		Qualitative	Very High
Offshore Technology/ Husseini, T	Transporting oil and gas: the world's longest pipelines		Qualitative	High
International Maritime Organization (IMO)	IMO 2020 – cutting Sulphur oxide emissions. Prevention of Air Pollution from Ships		Qualitative	Very High
International Gas Union	Global Gas Rapport 2020	Quantitative	Qualitative	High
Le Fevre, C	A review of demand prospects for LNG as a marine fuel		Qualitative	Very High

Mak, J., Mokhatab, S., Valappil, J., Wood, D	Handbook of Liquefied Natural Gas		Qualitative	Very High
McGlade, C., Speirs, J., Sorrell, S	Unconventional gas – A review of regional and global resource estimates (Volume 55)		Qualitative	Very High
Mokhatab, S., Poe, W, A	Handbook in Natural Gas: Transmission and Processing, (2nd edition)		Qualitative	Very High
Sandström, D., Waahler, O	En Kartläggning av den globala handeln med Liquefied Natural Gas, LNG	Quantitative	Qualitative	Midde
Speight, J, G	Natural Gas: A basic handbook (Second edition) Handbook of hydraulic fracturing (First Edition)		Qualitative	Very High
Statista/ Sönnichsen, N	Deepest oil and natural gas wells worldwide 2019 Number of liquefied natural gas storage vessels worldwide from 2010 to 2019 Natural gas consumption worldwide from 1998 to 2019	Quantitative	Qualitative	Very High
International Group of Liquefied Natural Gas Importers (GIIGNL)	LNG Informational Paper #3: LNG Ships		Qualitative	High
United Nations	The Paris Agreement		Qualitative	Very High
Tight, M	Documentary Research in the Social Sciences		Qualitative	Very High
Wang, H., Rutherford, D., Desai, C	Long-term energy efficiency improvement for LNG carriers		Qualitative	Very High

Note. This table lists organizations and sources used in this report for data analysis and their reliability.
Source: Own table

Information for this research was collected primarily from available internet sources. Collected data had to be analyzed for suitability and reliability. In order to gather the most reliable information, official websites of members in this industry and other universities that made that type of research are preferred. All sources had to be evaluated for authority, objectiveness, and trustworthiness and the rating can be seen in table 5. The websites used in this research was filtered by using a method described by Denscombe (2014) the authority it holds, the trustworthiness, how up to date the website is and how popular it is.

The statistics and information for BP, International Gas Union, International Group of Liquefied Natural Gas Importers and Offshore Technology has been deemed as highly reliable due to the fact it is from institutions who are experts within the energy sector. The reason for them not to be deemed as very high reliability is that these organizations might be inclined to present the natural gas market from a positive angle. This is because the organizations are dependent on the natural gas market.

All the work of Cheremisinoff, N and Davletshin, A, Cleveland, C, J and Morris, C, Denscombe, M, Mak, J., Mokhatab, S., Valappil, J and Wood, D, McGlade, C., Speirs, J., Sorrell, S, Mokhatab, S., Poe, W, A, Tight, M, and Wang, H., Rutherford, D. and Desai, C have all been deemed very highly reliable. This is because they are all textbooks written by experts within their respective fields.

The information from Holmes, C and Rogers, D, and Le Fevre, C is deemed very highly reliable because they are experts in their fields and work for institution with a high authority in their sectors.

Information from IMO and the United Nations has been deemed very highly reliable because they are big international agency's that work to positively impact the whole world.

The information from Statista is deemed as very highly reliable because it is a company specialized in market and consumer data. Statista can also be seen as an objective source, the reason for this is that the company presents statistics from many different markets and consumer aspects and would not be benefited to present the LNG market in a positive way.

The information from Sandström, D and Waahler, O have been rated as middle reliability due to the fact they are not experts in this field.

3.4 Ethics

This research is based on statistics and economical reviews presented in official annual rapports of major international organizations that can be treated as public documents. The analysis of information in this research do not involve or reveal any personal information that could harm the individual's private life or social status. Some persons named in this research history chapter must be interpreted as historical characters and are represented for their input in development of natural gas market.

Figures, table and information were chosen either because the trademark holder gave permission in their work that figures and table were allowed to be used without written permission if it was for educational purpose and non-profit. Or it was stated that the figure was part of public domain, but with the conditions that credit was given to the copyright holder.

4. RESULTS

This chapter describes the flow of natural gas in the global energy market. The information regarding consumption, production, import, and export were from BP's Statistical Review of World Energy 2020, and the predictions from International Gas Union's Global Gas Rapport 2020. Other information was collected from IMO's and Statista's official websites.

4.1 The natural gas market in 2009

The total amount of natural gas produced globally was 2934.9 billion cubic meters (bcm), and the total amount of consumption was 2941.1 bcm. In total there was 670.3 bcm traded in 2009, 62.7% was transported by pipelines and 37.3% by LNG carrier vessels. This means 420.6 bcm was transported by pipelines and 249.7 bcm of LNG were transported by the shipping industry (BP, 2020).

In 2009 there were 170.5 trillion cubic meters (tcm) of proved gas reserves. 43.2% were in the Middle East, 27.3% in The Commonwealth of Independent States (CIS) region, 8.3% in Africa, 8.2% in the Asian Pacific, 5.5% in North America 4.4% in South and Central America and 3.1% Europe (BP, 2020).

4.1.1 Production by Region

In 2009 North America produced 765.2 bcm of natural gas, making it the largest producer in the world this year. Mexico was the smallest producer in this region with 52.6 bcm, Canada was the second largest with its production of 155.1 bcm. The biggest by far was the United States, producing 557.6 bcm of natural gas. This did not only make it the largest producer in the North American region, but also the biggest compared to the rest of the countries in the world (BP, 2020).

The South and Central America region was the smallest producer in 2009 with only 152.3 bcm produced. Argentina was the largest producer within the region with 40.3 bcm, second largest was Trinidad and Tobago with 38.8 bcm, and Venezuela as third with 31.8 bcm produced (BP, 2020).

Europe produced a total of 303.7 bcm of natural gas, the biggest by far was Norway with its production of 103.6 bcm. The second biggest producer was the Netherlands with 65.5 bcm (BP, 2020).

CIS region was the second largest producers of natural gas in 2009. They produced 663.2 bcm with Russia as its biggest producer by far with its production of 536.2 bcm, this also made it the nation with the second largest production in the world. The second biggest producer in the region was Uzbekistan that produced 58.4 bcm (BP, 2020).

The Middle East region produced 413.8 bcm in 2009 making the fourth largest region with Iran as the largest producer within this region. Iran produced 135.7 bcm (BP, 2020).

The region of Africa produced a total of 192.1 bcm with Algeria as the biggest producer with its production 76.6 bcm, and the second biggest was Egypt with 60.3 bcm. The third biggest producer with just over a third of that was Nigeria with 23.2 bcm (BP, 2020).

The third largest producer in 2009 was the Asian pacific region, producing a total of 444.6 bcm. Within the region, China was the biggest producer by turning out 85.9 bcm of natural gas that year. The second biggest in this region was Indonesia who produced 78.0 bcm, and Malaysia as third with 66.2 bcm (BP, 2020).

4.1.2 Consumption by Region

North America was also the largest consumer of natural gas in 2009 with a total consumption of 769.4 bcm. Mexico had a consumption of 65.2 bcm, and Canada consumed 86.6 bcm. The United States was the biggest consumer by country in the world of natural gas with 617.6 bcm (BP, 2020).

In 2009 the South and Central American region consumed a total of 135.8 bcm. The biggest consumer within this region was Venezuela with 34.2 bcm (BP, 2020).

The European region was the second largest consumer in 2009, the region consumed a total amount of 577.4 bcm. The largest consumer within the region was the United Kingdom with 91.2 bcm, this also made it the third largest consumer by country this year (BP, 2020).

Despite the high production of natural gas in the CIS region the whole region only consumed a total of 499.9 bcm, making it the fourth largest consumer in the world this year. Russia was the biggest consumer in this region consuming 397.8 bcm, which represents 79.6% of the whole region. This made Russia the second biggest consumer by country in the world in 2009 (BP, 2020).

The Middle Eastern region was the fifth largest region and consumed 347.3 bcm of natural gas with Iran as the biggest consumer in the Middle East, with its consumption of 134.8 bcm (BP, 2020).

The African region was the smallest consumer with the entire region only consumed 95.6 bcm, with Egypt as its biggest consumer with 40.9 bcm (BP, 2020).

The total consumption in the Asian pacific region 2009 amounted to 515.6 bcm making it the third largest region. The biggest consumer of natural gas in this region was Japan with a consumption of 92.5 bcm followed closely by China with their consumption of 90.2 bcm (BP, 2020).

4.1.3 Imports by Region

The North America region imported a total of 135.6 bcm of natural gas. The United states was by far the largest importer within this region by importing 102.5 bcm in 2009 (BP, 2020).

The South and Central America region imported a total of 11.2 bcm where the biggest importer was Brazil with 8.1 bcm (BP, 2020).

The region of Europe was the largest importer by far in 2009 with a total import of 288.8 bcm (BP, 2020).

The CIS region imported a total of 61.2 bcm, with Russia accounting for 38.5 bcm. All the natural gas imported in 2009 were through pipelines (BP, 2020).

The Middle East imported 10.1 bcm of natural gas in 2009 (BP, 2020).

The African region did not import and natural gas that year (BP, 2020).

The Asian pacific region was the second largest importer, the total imported amount was 163.6bcm in 2009 (BP, 2020).

4.1.4 Exports by Region

In the North American region, there was a total of 119.0 bcm exported making it the second largest exporter. The United States exported 29.1 bcm (BP, 2020).

The South and Central American region exported a total of 27.1 bcm (BP, 2020).

In 2009 Europe exported 3.4 bcm making it the smallest region (BP, 2020).

The CIS region was the largest exporter with its 248.0 bcm exported, and 196.5 bcm were exported from Russia making it the largest exporter by country in 2009 (BP, 2020).

The Middle East exported 71.8 bcm of natural gas in 2009 (BP, 2020).

There was a total amount of 98.0 bcm exported from the African region, making it the third largest exporter in 2009 (BP, 2020).

The Asian region exported a total of 97.4 bcm of natural gas, Malaysia was the largest exporter in this region with a total of 30.4 bcm exported. This also mad Malaysia the second largest exporter by country in 2009. (BP, 2020).

4.2 The natural gas market in 2019

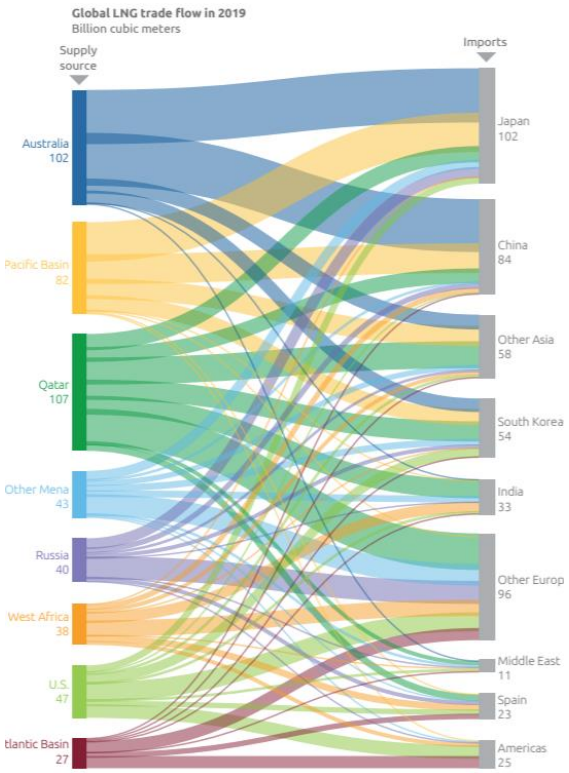
In 2019 the total production of natural gas worldwide was 3989.3 bcm and the consumption was 3929.2 bcm. The total amount traded worldwide was 984.4 bcm were 50.7% was transported by pipelines and 49.3% was transported by LNG carrier vessels. This means that 499.4 bcm was transported by pipeline and 485.1 bcm of LNG was transported by the shipping industry (BP, 2020).

In 2019 there were large investments made into the natural gas industry, there were commissions of pipeline routes between Russia, China, and Europe. There was also a new record for LNG export projects approved. During 2019 some of the largest new projects were the Arctic LNG 2 project from Russia, Golden Pass LNG from the United States and Mozambique LNG (International Gas Union, 2020).

In addition to the land-based investments, the world fleet of LNG carriers has grown in numbers in the last decade. In 2010 there were 360 LNG tankers worldwide, this number has gone up to 601 in 2019. This is to accommodate the growing need for transportation of LNG to satisfy the consumer demands (Statista, 2020). Some of major LNG trade patterns can be seen in figure 4.

In 2019 there were 198.8 tcm of proved gas reserves. 38.0% were in the Middle East, 32.3% in The CIS region, 8.9% in the Asian Pacific, 7.6% in North America, 7.5% in Africa, 4.0% in South and Central America and 1.7% Europe (BP, 2020).

Figure 4
Global LNG trade flow in 2019



Note. The graph shows major trade flow from exporters to importers in bcm.
Source: BloombergNEF 2020, International Gas Union, 2020, Global Gas Report 2020.

4.2.1 Production by Region

The North American region was the biggest producer in 2019, with a total of 1128.0 bcm of natural gas being produced, with the United States of America being the largest producers within the region. The United States produced 920.9 bcm not only making it the largest producer in the region, but also the world by country (BP, 2020).

In the South and Central America region the total amount produced was 173.6 bcm making it the smallest producers in 2019. The biggest producer in the region was Argentina with 41.6 bcm followed by Trinidad and Tobago with 34.6 bcm (BP, 2020).

In Europe there was 235.9 bcm of natural gas produced, the largest by far was Norway with a total amount of 114.4 bcm. The second biggest producer in this region was the United Kingdom with 39.6 bcm (BP, 2020).

In 2019 the CIS region produced 846.5 bcm making it the second largest producer by region. Russia was the largest producer in the region, producing 679.0 bcm making it the second largest producer by country in the world (BP, 2020).

The Middle Eastern region was the third largest producer of natural gas in 2019, the total amount produced was 695.3 bcm. The Largest producer within the region was Iran with a production of 244.2 bcm, followed by Qatar with 178.1 bcm (BP, 2020).

In 2019 the African region produced a total of 237.9 bcm of natural gas. The biggest within this region was Algeria with 86.2 bcm, second was Egypt with 64.9 bcm, and Nigeria as third with 49.3 bcm produced (BP, 2020).

The Asian pacific region produced a total of 672.1 bcm of natural gas in 2019. The two biggest by far was China with 177.6 bcm followed by Australia with 153.5 bcm. (BP, 2020).

4.2.2 Consumption by Region

In 2019 the North American region consumed 1057.6 bcm of natural gas, with the United States as the biggest consumer in the region with 846.6 bcm. This made the United States the world biggest consumer of natural gas. Canada consumed 120.3 bcm and Mexico was the smallest with 90.7 bcm (BP, 2020).

The South and Central America region consumed a total amount of 165.4 bcm making it the second smallest region in 2019. The biggest consumer within the region was Argentina with 47.5 bcm (BP, 2020).

Europe consumed a total amount of 554.1 bcm. Germany consumed 88.7 bcm making it the region's largest consumer, followed by the United Kingdom with 78.8 bcm (BP, 2020).

The whole CIS region consumed a total 573.7 bcm of natural gas, where Russia again was the biggest consumer, with a consumption of 444.3 bcm. This also made Russia the second largest consumer in the world by country (BP, 2020).

The Middle East consumed 558.4 bcm, with Iran as its largest consumer with 223.6 bcm. The second largest consumer within the region was Saudi Arabia with 113.3 bcm (BP, 2020).

The Africa region consumed a total of 150.1 bcm, this made the African region the smallest consumer by region. The largest consumer in the African region was Egypt with 58.9 bcm of natural gas (BP, 2020).

The Asian pacific region consumed 869.9 bcm, making it the second largest region by consumption after the North American region. China was the largest consumer within the region with 307.3 bcm, this also made China the third largest consumer of natural gas in 2019 (BP, 2020).

4.2.3 Import by Region

The North American region imported a total amount of 157.3 bcm, making them the third largest importer. A large amount of it was imported to the United States, who imported 74.8 bcm (BP, 2020).

The total amount of natural gas imported to the South and Central America region was 19.6 bcm (BP, 2020).

Europe imported 353.3 bcm making them the second largest importer in 2019 (BP, 2020).

The CIS region imported 56.0 bcm of natural gas. 26.8 bcm of the total amount was imported to Russia (BP, 2020).

The Middle East imported 11.3 bcm making it the second smallest region in regard to imports in 2019 (BP, 2020).

The African region did not import any natural gas in 2019 (BP, 2020).

The Asia region was the largest importer in 2019 with a total amount of 387.0 bcm (BP, 2020).

4.2.4 Exports by Region

North Americas exported 196.2 bcm in 2019, where the United States exported 122.9 bcm making it the highest in the region and the second biggest by country in the world (BP, 2020).

The Central and South American region exported a total of 28.7 bcm making it the second smallest exporter in 2019 (BP, 2020).

The European region was the smallest exporter in the world with only 8.6 bcm exported (BP, 2020).

The CIS regions exported 337.9 bcm making it the largest exporter, where a majority was exported from Russia. 256.6 bcm was exported from Russia making it the largest exporter by country in the world (BP, 2020).

The Middle East exported a total of 136.6 bcm of natural gas in 2019 (BP, 2020).

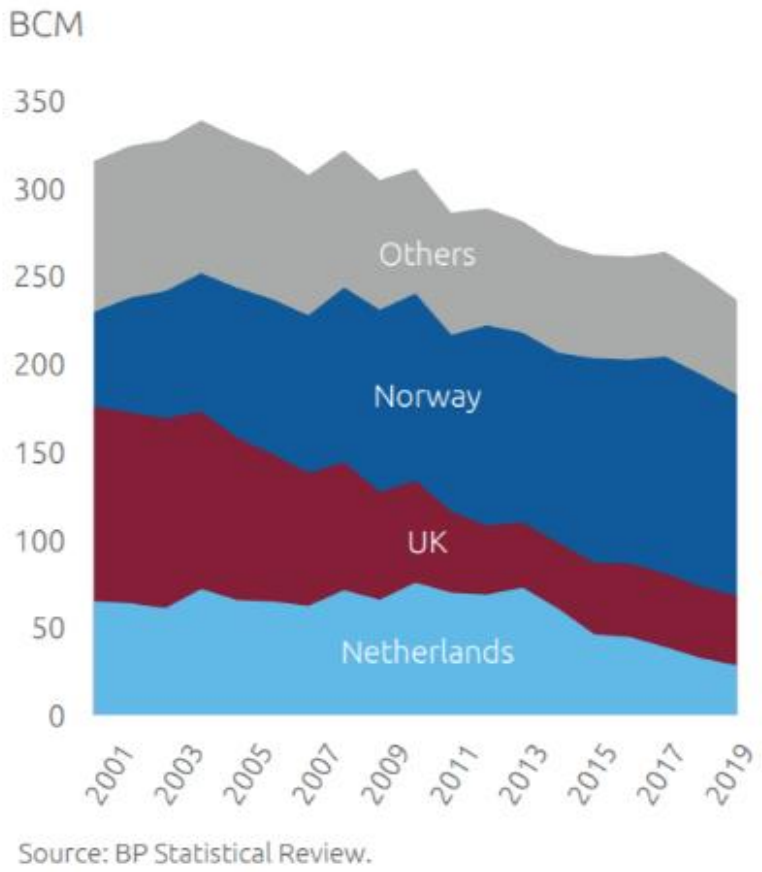
In 2019, a total of 89.5 bcm of natural gas was exported from Africa (BP, 2020).

The Asian Pacific was the region with the third highest amount exported. They exported a total of 186.8 bcm in 2019 (BP, 2020).

4.3 How and why the market has developed

The global natural gas consumption has over the past 15 years been growing (Statista, 2021). Despite regions like Europe having had an overall decline in production since 2005 as can be seen in figure 5, worldwide there have been higher amounts of both the production and consumption than the preceding year with 2009 being an exemption. According to experts a big part of the reason for the slight decline in 2009 was the global financial crisis that was taking place between 2007 and 2008 (Holmes and Rogers, 2009).

Figure 5
European Gas Production



Note. Graph shows the amount of natural gas produced in Europe bcm from 2001 to 2019. Source: BloombergNEF 2020, International Gas Union, 2020, Global Gas Report 2020.

There are multiple reasons why the natural gas market has grown to this extent and is expected to continue growing. Some big reasons are the fact that natural gas prices are considered to be affordable and natural gas is high in supply. In 2019 there were a proven total gas reserve of 199.0 tcm worldwide, with the Middle Eastern region having the largest proven reserve of 76.0 tcm. The region with the second largest proven reserves was the CIS region with 64.0 tcm together these two regions have over 70% of the global proven reserves. The region with the smallest proven reserves in 2019 was by far the European region with only 3.0 tcm. However, new discoveries of gas are still being made, and in 2019 the biggest discoveries were in Russia with Kara Sea, the Donkor and Nyarmeyskoye, in the Southeast Asia region with Yongle in the deep sea of south China, Lang Lebah in Malaysia and Kali Beray Dalam in Indonesia, and in Africa with the Orca in Mauritania and the Brulpadda which is discovery of condensate natural gas in South Africa. Even though the major discoveries were made in Russia, Southeast Asia, and Africa there were also discoveries of gas resiovoires from other parts of the world. Some being Glaucus located off the coast of Cyprus, Karish North located off the coast of Israel, West Erregulla in Australia and Bele, Tuk, Boom in Trinidad. There were also major discoveries of condensate natural gas in Iran called Eram and Glengorm located in the North Sea (International Gas Union, 2020).

Another significant reason for the natural gas markets growth is the shift towards less harmful energy sources. This can be seen in major markets like the United States and China having coal-to-gas switching initiatives. The outcome of better air quality and lower carbon emissions has also led other countries to slowly transition away from coal. India for example has commissioned new LNG import terminals and has planned to extend their gas transmission pipelines to almost twice the length that it is now (International Gas Union, 2020).

The problems concerning environmentally harmful emission from traditional types of fuel, such as heavy fuel oil in the shipping industry have been a problem for decades now. IMO is continuously working to implement regulations in order to reduce the emissions from the shipping industry. In 2005 the first regulations to reduce the emission of Sulphur, and in the last 15 years they have continued to reduce the allowed limit of Sulphur emission. The current regulation regarding Sulphur was implemented the first of January 2020, and the new limit for areas outside special limit areas such as SECA and ECA is 0.5%. In order to meet the new limit and to find a long-term sustainable economical solution shipping companies have had to convert existing ships and/or order new ones that either filtrate the exhaust gas or run on other, low-Sulphur types of fuel, such as LNG (International Maritime Organization, 2020).

To accommodate the growing demand of the energy resource many countries and companies have during the last decade built or expanded on existing natural gas refineries, pipelines, and terminals (Global Gas Report, 2020). In addition to the land-based investments, the world fleet of LNG carriers has grown in numbers during the last decade. In 2010 there were 360 LNG tankers in the global fleet. In 2019 that number had gone up to 601 (Statista, 2020).

4.4 What are the current prediction

The global demand for natural gas is predicted to keep increasing until the year 2040, and the global production is predicted to have average annual growth of 1.4%. This is believed to be because the overall need for new power sources and not necessarily for the need of natural gas. Within different regions different sectors drives the growing demands (International Gas Union, 2020).

4.4.1 Prediction by Region

The only region that is not predicted to have a rise in demand is Europe. The region is predicted to have an average annual decline of 0.4%. This is due to Europe moving towards renewable energy sources (International Gas Union, 2020).

In the Asia Pacific, the demand is connected to the growing need for industrial fuel. This region is believed to be one of the leading regions in the growing demand for natural gas, with a predicted average annual Growth of 2.9%. This is connected to China where the demand is predicted to have an average annual growth of 3.9%, and India with a prediction of average annual growth of 5.4%. The prediction of rising levels of consumption of natural gas is connected to economic growth, expansion of infrastructure and environmental protection initiatives like the coal to gas switch. Though in other parts of this region, like Japan and South Korea the demand for natural gas is believed to decline due to a likely resurgent of nuclear power (International Gas Union, 2020).

In the North American region, the demand for natural gas is predicted to have an average annual growth rate of 0.6%. In the United States and Canada, the reason for the predicted growth is the industry sector. While in Mexico it is connected to new power generating capacities (International Gas Union, 2020).

The Latin American regions average annual growth is predicted to be 1.8% within the next decades. This is due to the growing demand for electricity sources and a possible rising switch to natural gas as a fuel (International Gas Union, 2020).

The Middle East is predicted to have an average annual growth of 1.9 % in demand for natural gas. This is due to domestic consumption, growth in power generators and water desalination, and an increased effort to reduce emission (International Gas Union, 2020).

The African region is predicted to have the highest average annual growth rate of 3.2%. This is because the region not only has a fast-growing consumption but also production and the phasing out of oil as an energy source in power plants (International Gas Union, 2020).

4.4.2 Prediction by Sector

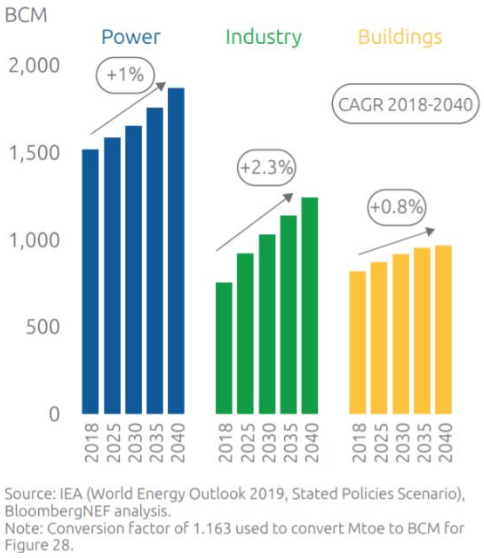
When looking at the natural gas growth within different sectors they are predicted to expand to different amounts as can be seen in figure 6, and for different reasons. The biggest sector today is the power sector, it is believed to stand for 50% of the natural gas demand over the next 5 years. It is also predicted to grow with an average annual rate of 1% in the next couple of decades (International Gas Union, 2020).

In the industry sector the average annual growth is predicted to be 2.3%. Markets in the regions where it is predicted to have the highest growth, like the United States and Eurasia. One of the main driving reasons to believe that the demand will grow is due to low and competitive prices (International Gas Union, 2020).

In the residential and commercial sector, the natural gas demand is only predicted to grow in a few countries due to expansion of gas distribution networks. For buildings, the average annual growth is 0.8% (International Gas Union, 2020).

The fastest growing demand for LNG will most likely be the transport sector, despite this being the smallest sector. The shift to natural gas as the fuel for light-weight vehicles, like busses and cars are not likely to have a high growing demand due to the advancement of electric vehicles. The major growth in demand is predicted to come from LNG-fueled trucks and vessels due to economic benefits and local environmental regulations (International Gas Union, 2020).

Figure 6
Predicted natural gas demand growth by sector



Note. Predicted annual growth rate for the different sectors until 2040.
Source: BloombergNEF 2020, International Gas Union, 2020, Global Gas Report 2020.

5. DISCUSSION

The purpose of this study was to show any interested person how natural gas the LNG market was developing with intervals of 10 years. As well as to provide the reader with the basic information about natural gas, its components, production method and transportation ways. In this report it was difficult to determine what factors that affect the market by making it grow, decrease or to be stable, although some of them are named and can be considered by the reader. Factors like crisis, war, sanctions, epidemics etc., were not analyzed in this rapport, due to the unpredictability of such large-scale events. Analyzing the changes for decades shows an overall picture and a tendency of market expansion that can be evaluated as stable and reliable. By doing that kind of research it is much easier to understand a line of development for certain regions and countries. By understanding the expansion or decrease of the market in a long term, the predictions for further development can be made.

5.1 How the natural gas market looked in 2009

In 2009 the total proved reserves were largely located in the Middle Eastern, the CIS and the African regions. This was reflected in the regions being able to produce a larger amount than they consumed. The Asian Pacific region had the fourth largest proven reserve. The fifth largest region regarding proven reserves was North America. The two smallest regions when it comes to total proved reserves were South and Central America, and Europe. This is reflected in the fact that the South and Central America region being the smallest producer and being the second smallest exporter this year. Europe with the smallest proven reserves was also the third smallest producer, the smallest by far in export and the second largest importer in 2009.

The North American region was the largest consumer and the biggest producer of natural gas. The region only consumed 4.2 bcm more than it produced. The region was almost able to meet the demand by domestic production and this led to them not having to import a greater amount to satisfy their needs. Despite this, with the high amount sold and exported out of the region, they also imported a large amount, and through the trade the region ended up with a surplus of 20.8 bcm.

The European region and the Asian Pacific region were not able to meet their demand through domestic production.

Europe was the second largest consumer this year, and the region produce 273.7 bcm less than it consumed. The European region did export a small amount of natural gas but had to import a large amount in order to satisfy the demand. With the import of 288.8 bcm Europe was the biggest importer and the region ended up with a surplus of 20.8 bcm.

The Asian Pacific region was the third largest consumer, but they too had a higher consumption than production. A total amount of 71.0 bcm more of natural gas were consumed than produced and the region exported 97.4 bcm. The need to import natural gas in the Asian Pacific region is reflected in the region's import of 163.6 bcm and the fact that the region must have used 4.8 bcm from existing stores.

The Central and South American, the CIS, the Middle Eastern and the African regions all produced more natural gas than they consumed.

The Central and South American region produced 16.5 bcm more than it consumed. When considering the facts that the region did import 11.7 bcm and exported 27.1 bcm, the region only ended up with a surplus of 0.6 bcm.

The CIS region produced 163.3 bcm more natural gas than it consumed. Together with the high amount exported and relatively small import the region utilized 23.5 bcm from existing stores in order to meet the consummation and export demands.

The African region produced 96.5 bcm more natural gas than it consumed. Due to a high amount exported and the fact that the region did not import any natural gas, the African region must have utilized 1.5 bcm from existing stores.

The Middle Eastern region produced 66.5 bcm more than it consumed and with its export of 71.8 bcm the region also imported 10.1 bcm to meet the demand. The region ended up with a surplus of 4.9 bcm.

5.2 How the natural gas market looked in 2019

In 2019 the two largest regions by proven reserves were still the Middle Eastern and the CIS regions. These two regions together with the African region, that were the fifth largest region by total proven reserves, were also able to produce more than they consumed. The third largest proven reserves were in the Asian Pacific region. They were the third largest exporters, and due to the fact, that they were also the second largest consumer they became the biggest importer as well. The fourth largest proven reserves were in North America, they were the biggest consumer and producers. The Central and South American, and the European regions were the smallest region ins proven reserves. In the case of the Central and South American region, this is reflected in them being the smallest producers. For Europe they were the second smallest producer, third smallest consumer, the second largest importer and the smallest exporter by far.

In 2019 the only two regions that consumed more natural gas than they produced were the European region and the Asian Pacific region.

The European region consumed a total of 318.2 bcm more than it produced, in addition to this the region also exported a total of 8.6 bcm of natural gas. The region as a whole imported 353.3 bcm, which means that they produced and imported enough natural gas to satisfy the demand and ended up with a surplus of 26.5 bcm.

The Asian Pacific region consumed 197.8 bcm more than it produced and they exported 186.8 bcm. With the region having had an import of 387.0 bcm, it shows that the Asian pacific region consumed and exported 2.4 bcm more of natural gas than it produced and import in 2019.

The North American, Central and South American, the CIS, The Middle Eastern, and the African regions all produced more natural gas than they consumed.

The North American region produced 70.4 bcm of natural gas more than it consumed. The region's imports amounted to 157.3 bcm. The region exported 196.2 bcm, and this shows that the region instead of exporting a large portion of the natural gas they instead choose to keep it and ended up with a surplus of 31.5 bcm.

The Central and South American region only produced 8.2 bcm more of natural gas than they consumed. With a total of 19.6 bcm imported and an export of 28.7 bcm, the region must have ended up having to utilize 0.9 bcm form existing natural gas stores.

The CIS region produced a total of 272.8 bcm more of natural gas than it consumed, and the region imported 56.0 bcm. The region was the biggest exporter by far with a total amount of 337.9 bcm exported. This means that a total of 9.1 bcm came from pre-existing stores.

The Middle Eastern region ended up producing 139.3 bcm more of natural gas than it consumed. The region imported 11.3 bcm, this means that with their export of 136.6 bcm the region as a whole ended up with a surplus of 14.0 bcm.

The African region produced a total of 87.8 bcm more than they consumed. The region did not import any natural gas and with an export of 89.5 bcm, 1.7 bcm must have come from existing stores.

5.3 How and why has the market developed

The global consumption and production have during the last 10 years been increasing, and the global import and export have grown from 670.3 bcm to 984.4 bcm. The total inter-regional trade increased by 46.9% during those ten years. The transportation by pipelines have increased by 18.8% and the LNG shipping have increased by 94.3% between 2009 and 2019.

When looking at the individual regions, all regions except the European region have all been expanding production to satisfy their growing need for natural gas. In Europe, the overall trend in natural gas consumption has gone down, and regarding productions the only country that has increased and not decreased their production is Norway. In the entire European region, 67.8 bcm less was produced in 2019 than in 2009. As a result of the consumption only decreased by 23.3 bcm, this has led to a large increase of import and only a small increase in export.

The rise in consumption and production led the different regions to trade in different ways. The North American region have increased their import and decrease their export. The Central and South American region, the Middle Eastern region, and the Asian region have all increased both imports and exports. The CIS region has decreased their import and increased their export. The African region has in 2019 like in 2009 decided not to import any natural gas and has slightly decreased their export.

The natural gas market has shown sufficient growth during the last decade and it depends on several reasons. Some of them are sufficient growth of availability on the market (new pipelines and vessels), new regulations concerning reduction of GHG and emissions from fossil fuels, as well as the increase of production from unconventional natural gas reservoirs.

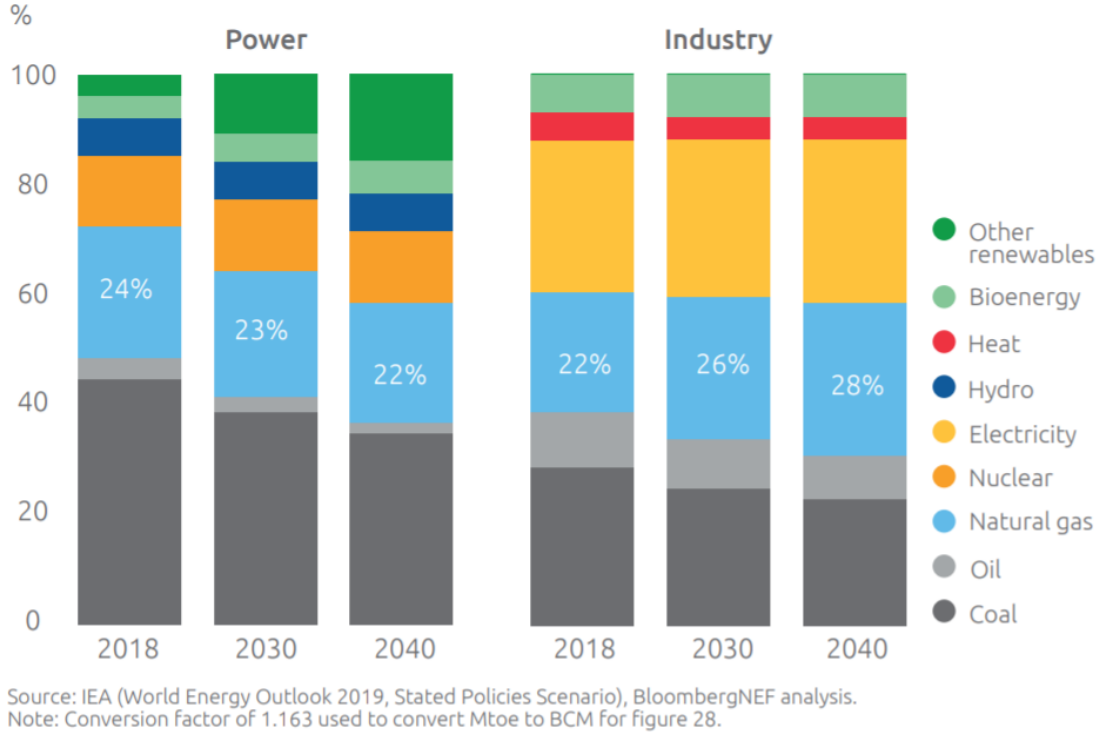
The development of new pipeline systems made it easier to transport large amounts of gas to storage stations located near industrial centers, from where it can be redirected for further usage.

The LNG fleet has expanded to a large degree during the last decade and has almost doubled the number of vessels transporting LNG from 360 in 2010 to 601 in 2019. The rising demand for transportation units leads to the conclusion that there was a rise in the demand of natural gas as the market responded fulfil its needs. The rise of transportation units has consequently led to the growth of storage stations and terminals worldwide.

5.4 What are the predictions

The demand for natural gas is predicted to be rising in most of the world with the exception for the European region. This prediction is based on the fact, that there is a need for energy sources rising all over the world, and that there has been a shift towards more environmentally friendly types of energy sources. Despite this, different sectors have been predicted to develop differently, one example of this can be seen in figure 6. There are many initiatives to decrease the CO2, NOx, and SOx emissions, especially moving away from coal in coal to gas initiatives. Even though natural gas is seen as preferable to traditional energy sources like oil and coal, markets like Europe have started and are believed to continue to move away from fossil fuels and towards renewable energy. Another reason for the global rising demand for natural gas is the existing investments to expand the natural gas and LNG infrastructure and technology, and the economic benefits of using natural gas due to the affordable prices.

Figure 7
Share of Natural Gas by sector



Note. This table shows the share of Natural gas compared to other energy sources in the power sector and industry sector from 2018, and the predictions for 2030 and 2040
Source: BloombergNEF 2020, International Gas Union, 2020, Global Gas Report 2020.

5.5 Result from previous research

In the previous research “En kartläggning av den globala handeln med Liquefied Natural Gas, LNG” written by Sandström and Waahler, they showed that the LNG trade had increased with almost 9.4% from 2011 to 2012. In their conclusion they predicted that the market would develop at a slower rate than it had in the year 2012. With an increase of 160.2 bcm from 2012 to 2019, that is an average annual growth of 7%. Meaning their conclusion was correct.

5.6 Method discussion

After a completed research, a type of method documentary research can be validated as the most suited and relevant. Using quantitative data from annual reports of big international organizations provided reliable and trustworthy information as these organizations have no economic or political interests to make the data look better to benefit them. Moreover, changing quantitative data could call in to question their authority in the energy sector. On the other hand, qualitative data used in annual reports has a high level of reliability because the organizations have a long history and have a high level of knowledge in their sectors. They still must be analyzed with some skepticism when drawing conclutions, due to the fact that the organizations are deeply involved in their sector and their annual report may affect stock market prices and raise awareness among the investors.

Special surveys and questionnaires were not included in this research due to unavailability to establish contact with companies’ representatives and experts in this area of research. Difficulties with reaching these experts were most likely dictated by the ongoing Covid-19 pandemics. Their accessibility was probably restricted due to changed work environments as all work in offices was restricted and switched to a remote working place. In addition to this their workload might have been increased due to how the pandemic have affected all aspects of industries and markets. These factors combined is likely to have affected their work schedules. No survey that was sent out received any answers. It would have been beneficial to get answers from experts directly involved in today’s market to get more precise and up to date answers to questions mentioned in this report.

6. CONCLUSION

6.1 How and why has the market developed

The natural gas market has been one of the fastest growing markets in the energy sector increasing with 46.9% in the last decade. In the period of time between 2009 and 2019, the LNG shipping market has expanded with 94.3% and the pipeline trade with 18.8%. Such a sufficient growth was dictated by the increased consumption, which for its part was affected by high availability and environmental benefits of natural gas. Moreover, the new environmental regulations like the Paris Agreement made countries search for an alternative energy solution to crude oil and coal. Even though natural gas is a fossil fuel by itself it has much lower emissions than other crude oil and coal products and is a good solution to rapid decrease of GHG emissions. This is a likely reason for the growth seen in the bigger well-established markets. Within the regions with the lowest consumption in 2009 the largest growth was probably connected to the investments and projects to build new and expand the existing infrastructure, and the fact that new discoveries of natural gas deposits have been and are still being made.

In the case of Europe there has been a clear shift away from consumption of natural gas but also in its production. This led to the European region having to import more to still meet the current demand. The reason for the shift away from natural gas is due to the European region being able to and choosing to move towards renewable energy sources.

In order to ensure the market will be sustainable and secure, new LNG terminals and new pipelines are built all over the world. With the increased capability of transporting larger volumes by different means, the market becomes more independent from regional producers of natural gas. This leads to a free market where different players can compete, and prices are regulated without intervention of monopolies.

6.2 The future

It is likely that the market will continue to grow to satisfy the need for natural gas as an energy source, but it will likely have a smaller part within the entire energy sector in the future. This is because even though natural gas is a good alternative to traditional fossil fuels. The fact that it is not renewable means at some point, the world as a whole will have to switch to renewable types of energy sources. As mentioned before this can already be seen in the European regions' consumption and its likely to keep declining even though all other regions are extending the natural gas production and trade.
For now, there are sufficient amounts of proven natural gas reservoirs, so natural gas could be a long-term solution until fossil free alternatives are developed enough to take over the main positions in the energy market.

6.3 Recommendations for further research

How energy efficient is natural gas compared to other energy sources?
What are the predictions for how big of a share will Natural gas have in the energy sector compared to other energy sources?
What are the environmental effects of natural gas all the way from extraction to usage?

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Göteborg, Sweden, 2021
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