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MASTER PROGRAMME IN ENERGY: STRATEGY, LAW AND ECONOMICS

Master΄s Thesis

«The interaction between global liquid energy markets and global maritime transport market»

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Η Μαρία Φιργιόλα βεβαιώνω ότι το έργο που εκπονήθηκε και παρουσιάζεται στην υποβαλλόμενη διπλωματική εργασία είναι αποκλειστικά ατομικό δικό μου. Όποιες πληροφορίες και υλικό που περιέχονται έχουν αντληθεί από άλλες πηγές, έχουν καταλλήλως αναφερθεί στην παρούσα διπλωματική εργασία. Επιπλέον τελώ εν γνώσει ότι σε περίπτωση διαπίστωσης ότι δεν συντρέχουν όσα βεβαιώνονται από μέρους μου, μου αφαιρείται ανά πάσα στιγμή αμέσως ο τίτλος.

(υπογραφή)

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Περίληψη

Σκοπός της παρούσας διπλωματικής εργασίας είναι να εξετάσει πώς αλληλεπιδρά η παγκόσμια αγορά υγρών ενεργειακών αγαθών με την παγκόσμια αγορά θαλάσσιων μεταφορών υγρών ενεργειακών αγαθών, ποίοι είναι οι παράγοντες που επηρεάζουν τις δυο αγορές, ποιες είναι οι τάσεις που επικρατούν επί του παρόντος, ποιες είναι προοπτικές ανάπτυξης αυτών και οι προβλέψεις για το μέλλον.

Η πρώτη ενότητα αναλύει την αγορά υγρών ενεργειακών αγαθών σε παγκόσμιο επίπεδο. Συγκεκριμένα, εξετάζονται τα παγκόσμια αποθέματα πετρελαίου και φυσικού αερίου, η κατανομή και εξέλιξή τους την τελευταία δεκαετία. Αναφέρονται παράγοντες που επηρεάζουν την μεταβλητότητα των τιμών πετρελαίου και φυσικού αερίου και οι δείκτες αναφοράς που χρησιμοποιούνται στην "spot" αγορά. Επίσης, αναλύεται η παγκόσμια προσφορά και ζήτηση των αγορών πετρελαίου και φυσικού αερίου και ειδικότερα του υγροποιημένου φυσικού αερίου (ΥΦΑ). Όσων αφορά την παραγωγή, αναλύεται η δυναμική των αγορών πετρελαίου και φυσικού αερίου από την πλευρά της προσφοράς σε παγκόσμιο επίπεδο, λαμβάνοντας υπόψη τις τιμές πετρελαίου, φυσικού αερίου και ΥΦΑ, την παραγωγή πετρελαίου και φυσικού αερίου, τις μεγαλύτερες εξαγωγικές χώρες και το εμπόριο. Αναφέρεται επίσης ο ρόλος που παίζουν οι χώρες του ΟΠΕΚ και οι εθνικές εταιρείες πετρελαίου και φυσικού αερίου. Αναφέρεται στο φαινόμενο της «κατάρας των πόρων» από το οποίο υποφέρουν πολλές μεγάλες χώρες εξαγωγής πετρελαίου και σε γεωπολιτικά θέματα που αφορούν το φυσικό αέριο. Όσων αφορά την ζήτηση, εντοπίζονται οι τομείς με τη μεγαλύτερη ζήτηση πετρελαίου και φυσικού αερίου τα τελευταία χρόνια και οι παράγοντες που επηρεάζουν την πρωτογενή ενεργειακή κατανάλωση παγκοσμίως. Καταλήγει στον εντοπισμό τάσεων στην παγκόσμια προσφορά και την ζήτηση την τελευταία δεκαετία και σε προβλέψεις μεσοπρόθεσμα και μακροπρόθεσμα.

Η δεύτερη ενότητα αναλύει τις θαλάσσιες μεταφορές υγρών ενεργειακών αγαθών και το διεθνές μεταφορικό σύστημά τους. Πρώτα, αναλύεται η παγκόσμια αγορά των δεξαμενοπλοίων που μεταφέρουν αργό πετρέλαιο και παράγωγά του, υγροποιημένο φυσικό αέριο και υγραέριο καθώς επίσης και πρόσφατες εξελίξεις όσων αφορά την ζήτηση και την προσφορά του στόλου. Γίνεται μια σύντομη περιγραφή των συνθηκών ανταγωνισμού αυτών των αγορών και αναφέρονται οι κύριοι ανταγωνιστές παγκοσμίως. Αναφέρονται απόψεις σχετικά με τη μέλλουσα κατάσταση των αγορών αυτών μεσοπρόθεσμα. Έπειτα, αναλύεται η διαμόρφωση της τιμής θαλάσσιας μεταφοράς, γίνεται σύγκριση στα μεταφορικά κόστη πετρελαίου και σύγκριση στα μεταφορικά κόστη φυσικού αερίου μέσω αγωγών έναντι των πλοίων. Στο τέλος της ενότητας, εντοπίζονται οι κύριοι λιμένες, οι διεθνείς μεταφορικές οδοί και οι εμπορικές ροές των ενεργειακών αυτών εμπορευμάτων.

Η τρίτη ενότητα αφορά το σύγχρονο θεσμικό πλαίσιο που διέπει τις θαλάσσιες μεταφορές υγρών ενεργειακών αγαθών καθώς επίσης και πρόσφατες εξελίξεις. Συγκεκριμένα, αναφέρεται στο ισχύον πλαίσιο όπως έχει ορίσει ο Διεθνής Ναυτιλιακός Οργανισμός (IMO), στο ευρωπαϊκό πλαίσιο, πολιτικές της Ευρωπαϊκής Ένωσης για τη ναυτιλία και στο ελληνικό θεσμικό πλαίσιο.

Η τέταρτη ενότητα αναλύει τους προσδιοριστικούς παράγοντες που επηρεάζουν την διεθνή αγορά υγρών ενεργειακών αγαθών από την πλευρά της ζήτησης και της προσφοράς. Στη συνέχεια, εξετάζεται πως η ενεργειακή αγορά επηρεάζει την αγορά θαλάσσιων μεταφορών αναλύοντας δεδομένα τριών μεταβλητών: την παγκόσμια ετήσια παραγωγή, την τιμή των αγαθών και την τιμή των ναύλων.

Η πέμπτη ενότητα αναλύει τις τάσεις και τις προοπτικές των δυο αγορών και συμπεραίνει.

Abstract

The purpose of this thesis is to examine how the global liquid energy market interacts with the global maritime transport market of liquid energy commodities, the factors affecting the two markets, the trends that currently prevailing and the prospects for growth in the future.

The first section analyzes the global market for liquid energy products. In particular, global oil and gas reserves are being examined, as well as their distribution and evolution over the last decade. Factors affecting the volatility of oil and gas prices and benchmarks used in the spot market are referred. It also analyzes the global supply and demand of the oil and gas markets, in particular liquefied natural gas (LNG). In terms of production, the dynamics of global oil and gas markets are analyzed, taking into account oil, gas and LNG prices, oil and gas production, major export countries and trade. It also mentions the role that OPEC and national oil and gas companies play in international oil and gas markets. It refers to the phenomenon of the "resource curse" that many large oil exporting countries suffer from and geopolitical issues concerning gas. In terms of demand, it identifies sectors contributing to the largest demand for oil and natural gas in recent years as well as factors affecting primary energy consumption worldwide. It results in the identification of trends in global supply and demand over the last decade and forecasts in the medium and in the long term.

The second section analyzes the maritime transport of liquid energy goods and their international transport system. First, it analyzes the tankers global market transporting crude oil and its derivatives, liquefied natural gas (LNG) and liquefied petroleum gas (LPG) as well as recent developments in fleet demand and supply. A brief description of the competition conditions of these markets is made and the main competitors are reported globally. Different views are examined on the future situation of these markets over the medium term. Next, it analyzes the maritime transport price formation, transport costs of oil and transport costs of gas through pipelines versus LNG vessels are compared. At the end of the module, major ports, international transport routes and trade flows of liquid energy commodities are identified.

The third section concerns the modern institutional framework governing maritime transport of liquid energy goods as well as recent developments. In particular, it refers to the international framework enforced by International Maritime Organization (IMO), European policies on shipping and the Greek institutional framework.

The fourth module analyzes the determinants that influence the international market for liquid energy products on the demand and supply side. It then examines how the energy market affects maritime transport market by analyzing historical data of three variables: world annual output, commodity price and freight rate.

The fifth section analyzes the trends and prospects of the two markets and concludes.

Introduction

Energy has always been indispensable for human survival. During much of the Cold War era, international security energy issues and accompanying arguments were dominant. International Political Economy of energy, more specifically energy realism, considers energy a key strategic good. Abundance of energy resources is internal strength for those states that have access to them and source of external dependency, and thus vulnerability, for those that do not. (Kathleen J. Hancock, 2014) Energy security of supply has been a much debated issue and it has been cause of intergovernmental disputes. Control over oil and gas reserves is an essential component of national power and driver of global conflicts, even wars between countries. Oil and gas are, after all, the world's most important and valuable commodities and constitute major source of income for the governments and corporations that control their production and distribution. Indeed, the governments of Saudi Arabia, Iraq, Nigeria, Russia, and South Sudan derive the great amount of their revenues from oil sales, while the major energy firms, many of them state-owned, exercise immense power in the above mentioned and the other countries involved.

Energy is commonly defined as the ability to do work or to produce heat. Energy manifests itself in many forms: heat, light, motive force, electrical, chemical, nuclear, and gravitational. As energy can be obtained from various sources, it is customary to classify them under the following different categories.

Energy forms are divided into (Bhattacharyya, 2011) (Bhattacharyya, 2011):

- Primary and Secondary

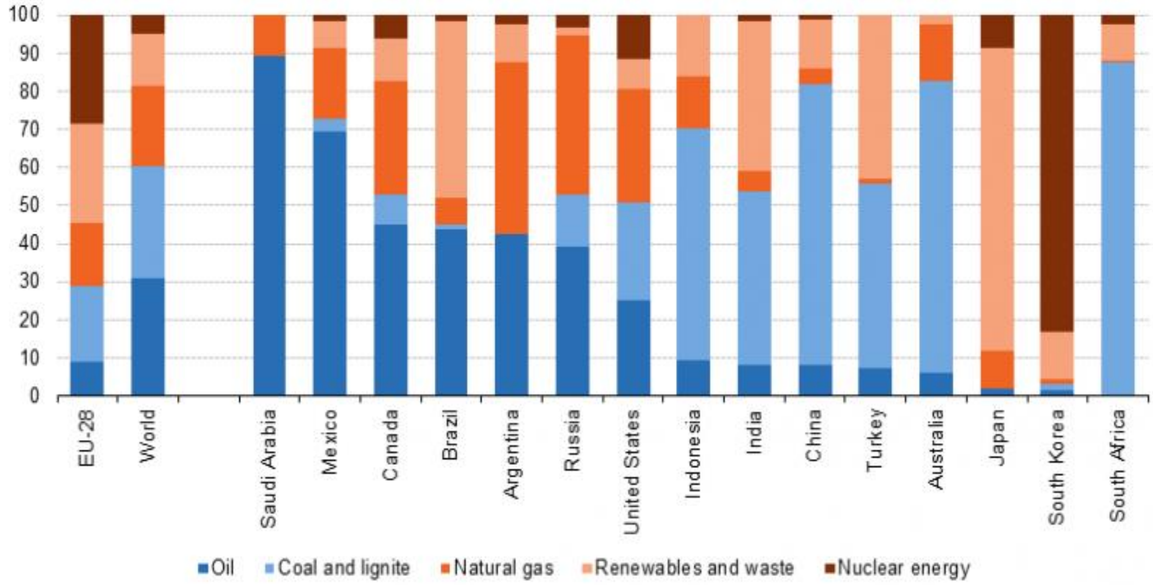
The term primary energy is defined as an energy source that is extracted from a stock of natural resources or captured from a flow of resources and that has not undergone any transformation or conversion other than separation and cleaning. Examples include coal, crude oil, natural gas, solar power, nuclear power, etc. On the other hand, secondary energy refers to any energy that is obtained from a primary energy source employing a transformation or conversion process. Hence, oil products or electricity are secondary energies as these require refining or electric generators to produce them.

- Renewable and Non-Renewable

Any primary energy which is obtained from a constantly available flow of energy is known as renewable energy. There are five main renewable energy sources: Solar, wind, geothermal, biomass, and hydropower. On the other hand, a non-renewable source of energy is one where the primary energy comes from a finite stock of resources. Drawing down one unit of the stock leaves lesser units for future consumption in this case. The main non-renewable energy sources are: crude oil, natural gas, coal, uranium (nuclear energy). Crude oil, natural gas, and coal are mixtures of hydrocarbons which are called fossil fuels because they were formed over millions of years by the action of heat from the earth's core and pressure from rock and soil on the remains (or fossils) of dead plants and creatures like microscopic diatoms. Fossil fuels currently supply most human energy requirements. Uranium is the fuel most widely used by nuclear plants for nuclear fission. Uranium is considered to be a nonrenewable energy source, even though it is a common metal found in rocks worldwide. Nuclear power plants use a certain kind of uranium, referred to as U-235, for fuel because its atoms are easily split apart. Although uranium is about 100 times more common than silver, U-235 is relatively rare. (Anon., n.d.)

Where do we mostly produce energy from? World energy supply comes mainly from fossil fuels, accounting for more than 80% of the total share, with renewable sources and nuclear power rounding out the mix. Primary production of energy is any extraction of energy products in a useable form from natural sources. This occurs either when natural sources are exploited (for example, in coal mines, crude oil fields, hydro power plants) or in the fabrication of biofuels. Transforming energy from one form into another, such as electricity or heat generation in thermal power plants (where primary energy sources are burned), is not primary production.

Figure 1: Primary production by energy type (excluding heat), 2013



Source: Eurostat and IEA (Balances)

Figure 1 illustrates primary production by energy source. Primary production of energy worldwide in 2013 reached 13.594 Mtoe and the members of the G20 accounted for approximately 72% of the world's energy production. For many of the G20 members the mix of energy sources for primary production in 2013 was dominated by just one type. In South Africa, Australia, China and Indonesia close to three quarters of the primary production came from coal and lignite and it almost reached half of the production in Turkey and India. In Saudi Arabia and Mexico oil was dominant, while in South Korea nuclear energy contributed by far the largest share and in Japan (after the Fukushima accident) the main source of primary production was renewables and waste. Production in Brazil, India and Turkey was a mixture from renewables and waste as well as one type of fossil fuel. By contrast, Argentina, Canada, Russia and the United States had substantial shares of production spread across two or three types of fossil fuels. By contrast, Argentina, Canada, Russia and the United States had substantial shares of production spread across two or three types of fossil fuels. Energy production in the EU-28 was more varied than in any of the other G20 members, with every one of the five types of energy sources to contribute less than 30%. Between 2003 and 2013, global primary production of energy increased by 32% (see Table 1). China's primary production increased 84% during this period, while output in Indonesia increased by 80%. Japan's production fell by 71%, in large part due to a fall in output from nuclear energy following the Tōhoku earthquake and tsunami on 11 March 2011. The EU-28 had the third largest fall in production (by 16%), reflecting supplies becoming exhausted and/or producers considering the exploitation of limited resources uneconomical.

Global gross inland energy consumption[1] was 13.541 Mtoe in 2013 (see Table 1) and the G20 members accounted for 79%. Global gross consumption increased 31% between 2003 and 2013, with Japan, the EU-28 and the United States the only G20 members to record lower consumption in 2013 than 10 years earlier due to economic recession, energy saving policies and to the use of the of renewable energy sources. China's gross inland consumption more than doubled (111%), while Saudi Arabia, India and Turkey also recorded increases in excess of 50%.

Table 1: Energy and international trade in 2003 and 2013

	Production		Imports		Exports		Gross inland consumption (¹)	
	2003	2013	2003	2013	2003	2013	2003	2013
EU-28	937.1	790.4	1 349.6	1 441.8	446.5	533.4	1 803.5	1 666.6
World	10 268.5	13 594.1	3 913.0	5 202.9	3 863.0	5 248.6	10 340.9	13 541.3
Argentina	86.1	71.4	1.9	16.7	26.0	4.7	60.9	80.6
Australia	254.1	343.9	28.1	50.9	167.7	260.6	109.5	129.1
Brazil	178.3	252.9	46.7	74.8	21.6	29.1	199.0	293.7
Canada	384.1	435.1	73.5	78.1	209.9	262.7	248.4	253.2
China	1 397.7	2 565.7	136.6	551.9	96.5	48.0	1 426.7	3 009.5
India	379.0	523.3	116.2	327.1	16.4	72.4	471.7	775.4
Indonesia	255.2	460.0	35.1	55.5	123.8	301.3	165.7	213.6
Japan	96.8	28.0	430.5	454.8	6.2	17.8	510.5	454.7
Mexico	229.1	216.5	26.7	54.8	102.5	76.5	149.2	191.3
Russia	1 119.5	1 340.2	28.7	27.4	486.8	620.3	645.3	730.9
Saudi Arabia	506.4	614.5	2.8	24.8	391.7	444.6	112.6	192.2
South Africa	153.4	165.7	22.8	35.1	54.1	54.9	117.7	141.3
South Korea	34.9	43.6	204.2	291.0	32.0	56.9	198.7	263.8
Turkey	24.1	32.3	54.4	95.6	3.1	8.9	74.2	116.5
United States	1 655.8	1 881.0	714.9	582.5	85.8	274.2	2 255.9	2 188.4

Source: Eurostat statistics

Energy usage varies among different economic sectors. These are industrial, transportation, residential, commercial and public service and agriculture. Table 2 shows the world energy use by sector, according to International Energy Agency's (IEA) measurements, in comparison with the years 2004 and 2013. The numbers represent the consumption of energy in Mtoe delivered to end users. Industrial users (metals industry, food, paper, wood, mining, manufacturing, and construction) consumed 29% of the total global energy use in 2013. The industrial sector accounts for the largest share of delivered energy consumption. Transportation of people and goods consumed a significant amount, 27.6% of the total. Other sectors include residential, commercial and public services and agriculture, which all contribute to 34.6% of the total consumption. Residential concerns heating, lightning and appliances and commercial (lighting, heating and cooling of commercial buildings). Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel.

There are clearly increases in final energy consumption both of industrial and transportation sector by approximately 2% from 2004 to year 2013. This trend for increase can be primarily a result of increase in demand of the two sectors. On the other hand, other sectors' category has declined by 4% over the 9 years, which can indicate either a decline in demand of those sectors

[1] Gross inland consumption, is the total energy demand of a country or region. It represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration. This covers: consumption by the energy sector itself; distribution and transformation losses; final energy consumption by end users; and statistical differences.

or an increase of energy efficiency[2]. Overall, there is a total increase in global energy consumption by 21.7% between the 9 years in comparison.

Table 2: World final energy consumption by sector

Year	2004	2013	2004	2013
Sector	**Mtoe**		**%**	
Industry	2.058,34	2.702,44	26,9	29,1
Transport	1.974,54	2.563,52	25,8	27,6
Other sectors	2.932,62	3.214,34	38,4	34,6
Non-energy use	678,88	820,76	8,9	8,8
Total	**7.644,38**	**9.301,06**	**100,0**	**100,0**

Source: IEA 2006 & 2015, Key World Energy Statistics

World economic growth, as measured in gross domestic product (GDP)[3], is a key determinant in the growth of energy demand. As countries develop and living standards improve, energy demand grows rapidly. For instance, in nations experiencing fast-paced economic growth, there is often increased demand for improved housing by a large share of the population, increased demand for appliances and transportation equipment, and growing capacity to produce goods and services, which lead to higher energy consumption. Over the past 30 years, world economic growth has been led by the non-OECD[4] countries, accompanied by strong growth in energy demand in the region. From 1990 to 2012, real GDP grew by 4.9% per year in non-OECD countries, compared to 2.1% per year in OECD countries. World economic growth has been steady in recent years, with the global economy growing by 4.0% in 2011, followed by more modest growth of 3.1% in 2012, 3.2% in 2013, and 3.3% in 2014. (U.S. Energy Information Administration, 2016). According to IMF (World Economic Outlook 2017) global growth was 3.1% in 2016. Global economic activity is estimated to pick up pace in next years, in both advanced economies and EMDEs (Emerging Markets and Development Economies). Global output is projected to grow in 2017–18, at 3.4% and 3.6 %, respectively.

Besides future economic growth, an important driver of global energy demand is policy commitments, such as the global agenda for reducing climate change and concerns for energy security. These global policies have caused the widespread adoption by governments of targets for reducing GHG emissions or increase renewable energy use and energy efficiency targets. Natural gas is the most favored commodity from the above policies as it is regarded “clean” source of energy out of the fossil fuels.

With constantly growing worldwide energy demand it is one of the main challenges for the 21st century to secure sufficient energy supply at reasonable costs in alignment with environmental and climate protection targets.

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[2] Energy efficiency is a way of managing and restraining the growth in energy consumption. It is the use of technology that requires less energy to perform the same function. For example, when a compact florescent light (CFL) bulb uses less energy (one-third to one-fifth) than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient. On the other hand, it should not be confused with energy conservation that is any behaviour which results in the use of less energy. Turning the lights off when leaving the room and recycling aluminium cans are both ways of conserving energy.

[3] Gross domestic product (GDP) measures the total market value of all final goods and services produced within a country during a given period.

[4] It is referred in countries that are not part of the Organization of Economic Cooperation and Development (OECD).

1. Global Market of liquid energy commodities: Oil and Liquefied Gas

Commodity[5] is a marketable item produced to satisfy needs which is traded internationally and is identified by almost the same characteristics, quality and value. Commodities are mostly used as inputs in the production of other goods or services and are traded in bulk on a commodity exchange or spot market. Energy commodities are almost synonymous with fossil fuels, mined and sold on global commodity markets. According to Standard International Energy Product Classification (SIEC)[6], the main energy commodities are coal, peat, oil (oil shale/oil sands, conventional crude oil), oil products, natural gas, natural gas liquids, biofuels (ethanol), electricity, uranium/nuclear power. *Energy commodities* can be either primary or secondary. (OECD, IEA, Eurostat, 2005) Primary energy commodities are drawn (extracted or captured) directly from natural reserves or flows like crude oil, natural gas and coal, whereas secondary commodities are produced by conversion or transformation of primary energy commodities. For instance, the production of petroleum products like gasoline from crude oil represents production of a secondary commodity from a primary one. Therefore, this dissertation will examine *liquid energy commodities* which include oil (conventional and unconventional), oil products, LNG and LPG.

Oil and natural gas constitute economic goods whose main characteristic is scarcity. They provide utility to society and because of the scarcity they are valuable, in other words consumers are willing to pay a price in order to acquire them. They also have opportunity cost, that is consumers are forced to make a choice among alternatives. Energy resources are transported long distances and create powerful interlinkages between countries requiring high intensive capital investments. Oil and natural gas as natural resources are limited in relation to the various needs and not equally allocated among countries. *Reserves* according to (Society of Petroleum Engineers, n.d.), are those quantities of oil and gas which are anticipated to be commercially recovered from a given date forward. They are physically located in reservoirs deep underground and cannot be visually counted, but rather are estimates. Since all estimates involve a relative degree of uncertainty, they can be distinguished into proved and unproved reserves. Within the unproved reserves group, they distinguish probable and possible reserves. (Society of Petroleum Engineers, n.d.) *Proved Reserves*, by definition, are those quantities that geological and engineering information indicates that can be commercially recovered in the future with reasonable certainty, at least 90% probability, from known reservoirs under existing economic conditions, operating methods and government regulations. However, proved reserves are usually based on government announcements and official estimates which are available in the public domain i.e. OPEC Secretariat. Meaning that are declared data for which nobody can be 100% certain to be the reality. *Probable and possible reserves* are less likely to be recovered with at least 50% and 10% probability respectively.

Proved reserves are mostly discovered and concentrated in specific countries; therefore they have become exporting countries and the exploitation of these resources constitutes significant share of their domestic economy, while other countries are depending on imports because they have no access to these resources. About 70% of global conventional oil and natural gas reserves are concentrated inside a so called "Strategic Ellipse[7]" stretching from Middle East to

[5] https://en.wikipedia.org/wiki/Commodity, accessed on 15.09.2016

[6] List of internationally agreed definitions of energy products which arranges them in a statistical classification.

[7] See more about the Strategic Ellipse at http://www.cambridgeforecast.org/GLOBALIZATIONTRENDS/STRATEGIC-ELLIPSE.html

the North of Western Siberia. Main consuming regions of both oil and gas in 2015 were Europe, Asia-Pasific and North America.

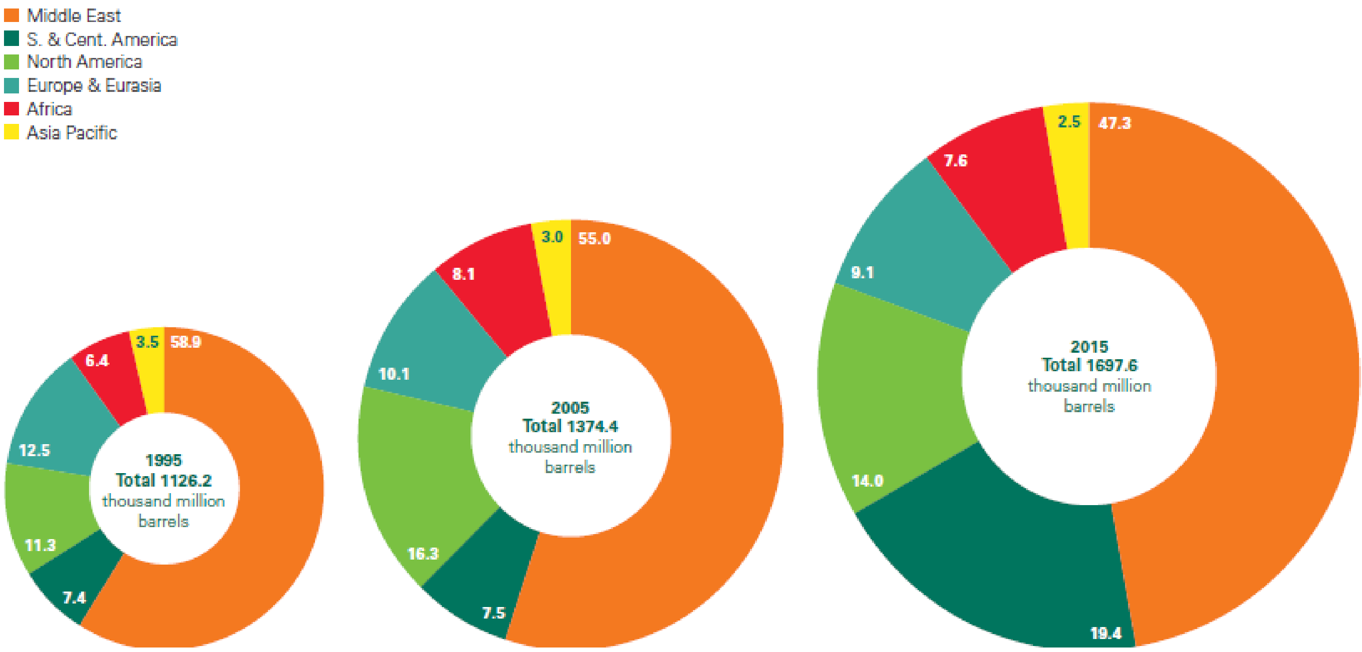
On the demand side, growth in both oil and natural gas consumption is coming from non-OECD and developing countries due to their rising economic growth surpassing advanced countries' demand. According to (British Petroleum, 2016) global oil consumption increased by 1.9 million b/d in 2015, nearly double the 10-year average. The Asia Pacific region accounted for 74% of global growth, with China once again contributing the largest national increment to global oil consumption growth (+770,000 b/d). Global gas consumption growth accelerated by 58.4 bcm in 2015 from a very weak 2014, but remained below the 10-year average. The Middle East recorded the strongest regional growth rate (+6.2%), while consumption in Europe & Eurasia declined by 0.3%, with a decline in Russia offsetting growth in the EU.

On the supply side, based on data of the BP's statistical review of 2016, the vast majority of oil and gas proved reserves are found in Middle East where most of the countries are oil and gas exporters. Oil accumulations which are found in the Middle East area accounts for 47.3% share of the total and gas accumulations in Middle East accounts for 42.8% of the total proved natural gas reserves. Important amounts of oil proved reserves are located in Venezuela and Saudi Arabia accounting for 17.7% and 15.7% of the global total respectively. As far as natural gas proved reserves are concerned, significant amounts are found in Iran and Russian Federation accounting for 18.2% and 17.3% of the global total respectively.

Based on BP's data of 2016, total world proved oil reserves reached 1697.6 billion barrels at the end of 2015, sufficient to meet 50.7 years of global production. Total world proved natural gas reserves in 2015 reached 186.9 trillion cubic meters (tcm), sufficient to meet 52.8 years of current production. The estimates of proved oil reserves have systematically been increasing over the years (see Figure 2). This means that people invest in exploration and exploitation of this resource type. The number has changed from 1.1 trillion barrels in 1995 to 1.3 trillion barrels in 2005, an increase of 22%. The last decade oil proved reserves increased 24%, accounting for approximately 1.7 trillion barrels in 2015. This increased in not only caused by new discoveries but also by the constantly changing economic conditions. In other words, the price of oil has significantly increased the last decade, until 2014 and beyond, and as a result already known oil fields have become commercially recoverable, which were not considered as proved reserves twenty years ago. Another major change lies in the composition and the distribution of them. Twenty years ago, it was considered that there was extreme dependency on the Middle East countries especially in the perspective of the future. Nevertheless, the share of the Middle East has systematically declined, from 59% in 1995, to 47.3% in 2015 (see Figure 2). The region that experienced the fastest growth is South and Central America. These regions accounted for 7.4% of the total proved reserves 20 years ago to 19.4% in 2015. There has also been some change in the role of Africa that has increased from about 6% to 8%, then declined slightly. But it is expected that the role of Africa will further increase in the coming years, in the next decades, due to ongoing new discoveries in that continent.

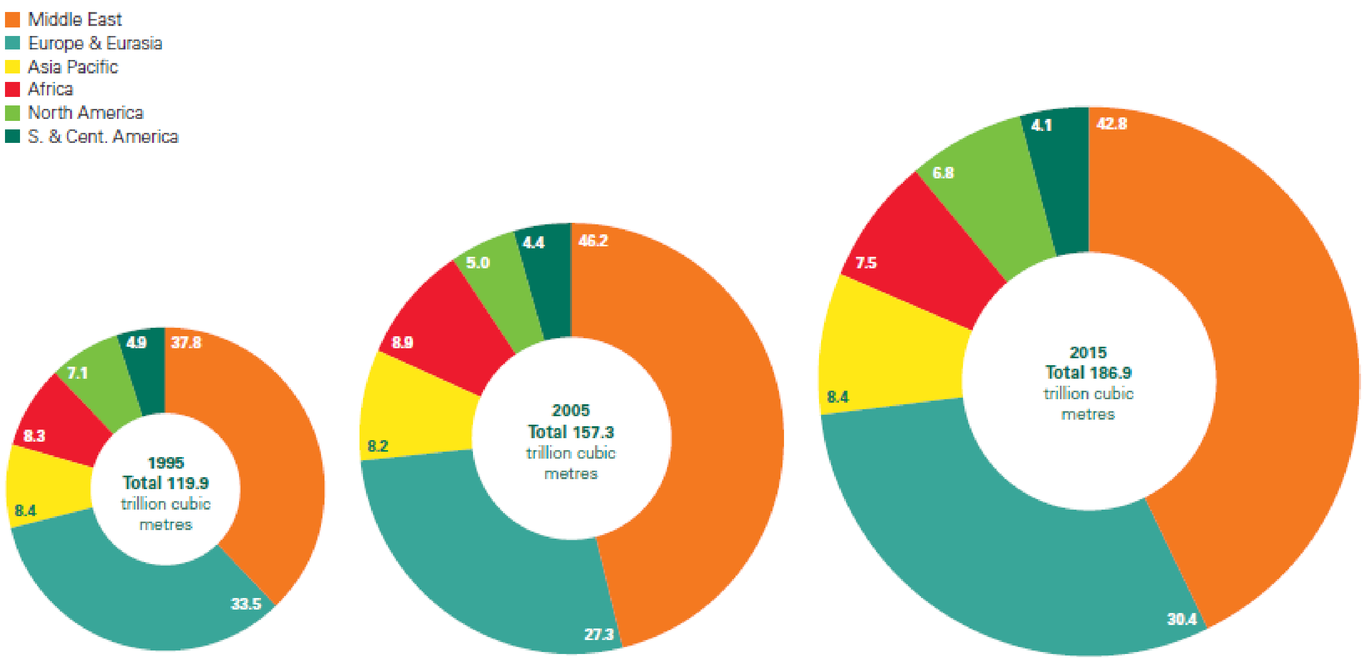
As was the case for oil reserves, the estimates of proved gas reserves have also been increasing over the years (see Figure 3). The number has changed from 119.9 tcm in 1995 to 186.9 tcm in 2015, an increase of 55.9%. Overall, the gas reserves have increased more in relation to oil but the distribution of these reserves is more balanced, in the sense that there is not significant change; Middle East remains very important (Figures 2, 3). The share of the Middle East remains almost the same over the years. Europe and Eurasia contribute an important region in proven gas reserves. In fact, a significant amount of the world gas proved reserves is located in the Caspian Region, which holds 46% of the world's total. As of 2015, almost 90% of natural gas reserves are in non-OECD countries, mainly Russia and the Middle East.

Figure 3: Distribution of proved crude oil reserves



Source: BP Statistical Review of the World Energy 2016

Figure 2: Distribution of proved gas reserves



Source: BP Statistical Review of the World Energy 2016

The first section will examine two key commodities of the energy market that are oil (both conventional and unconventional, excluding biofuels) and LNG. Although, LNG market is developing rapidly worldwide, natural gas market cannot be excluded since the former constitutes segment of the latter. The three subsections of this chapter will be divided into two categories of oil and natural gas market which will be analyzed separately. As far as the natural gas market is concerned, emphasis will be given on the LNG market.

1.1 Global Supply

This subsection analyses the dynamism of oil and gas markets from the supply side in a global level, by considering oil, natural gas and LNG prices, oil and gas production, exporting countries and trade.

1.1.1 Oil Prices

Because of oil's great economic importance historically, oil markets have always been subject to political regulations and interventions. Figure 4 depicts the historical spot prices for crude oil. Clearly, the oil price is influenced by events that have the potential to disrupt the flow of oil and products to market, including geopolitical, military (especially in oil-exporting countries) and weather-related developments. It is evident that several such issues like Arab Oil Embargo (1973), the Iranian Revolution (1979), the Iran-Iraq war, the Persian Gulf War (1990/91), unrest in Venezuela (2002), hurricanes in 2005, have all contributed to fluctuations in crude oil price. In addition, there are economic developments, such as the increase of energy demand in Asia or the financial crisis following the bankruptcy of Lehman Brothers in 2008, which have an impact on the oil price.

Empirical researchers (O'Sullivan, 2011) (Hvidt, 2013) distinguish the following five periods in oil price regimes: from 1990 to 1997, from 1997 to 2003, from 2003 to 2009, from 2009 to 2013, and from 2014 until the present day. In 1990, Iraq invaded Kuwait, which affected the oil prices and marked the first oil price regime through the Gulf War. Oil prices fell to USD 14.74 per barrel in 1994. Due to a rise in oil consumption, oil prices increased again in 1997 along with the Asian currency crisis. By 1998, OPEC countries[8] had increased production while consumption was low and oil prices fell again. In 2003, the US invasion of Iraq marked the end of the second oil price regime. Oil prices reached record highs by July 2008, due to several factors such as low oil inventories among developed countries in combination with rising demand and the damaged production capacity in Iraq. From January 2007 to July 2008, oil prices increased by more than 150%. By June 2009, prices came down dramatically due to the great global recession (Lehman Brothers bankruptcy) with a record 75% decline. After the recovery from the global recession, the economy started to bounce back in 2010. In 2011, oil prices rose, which continued until 2012. By mid-2014, oil prices collapsed by roughly 60%. In June 2014, Brent crude oil was around USD 116 per barrel. At the end of January 2015, it had fallen below USD 49 per barrel. The drop came due to both a pronounced slowdown in demand growth and an increase in non-OPEC supply growth.

In general, oil market is a mature global industry, with a large variety of different oil qualities (viscosity, sulphur content) and with different means of transportation (pipeline, shipping). All of these characteristics influence the oil price. Nevertheless, a liquid[9] oil market has developed, using different oil qualities as benchmarks, i.e. a reference price, for buyers and sellers' transactions. The prices of these benchmarks are used by oil companies and traders to price

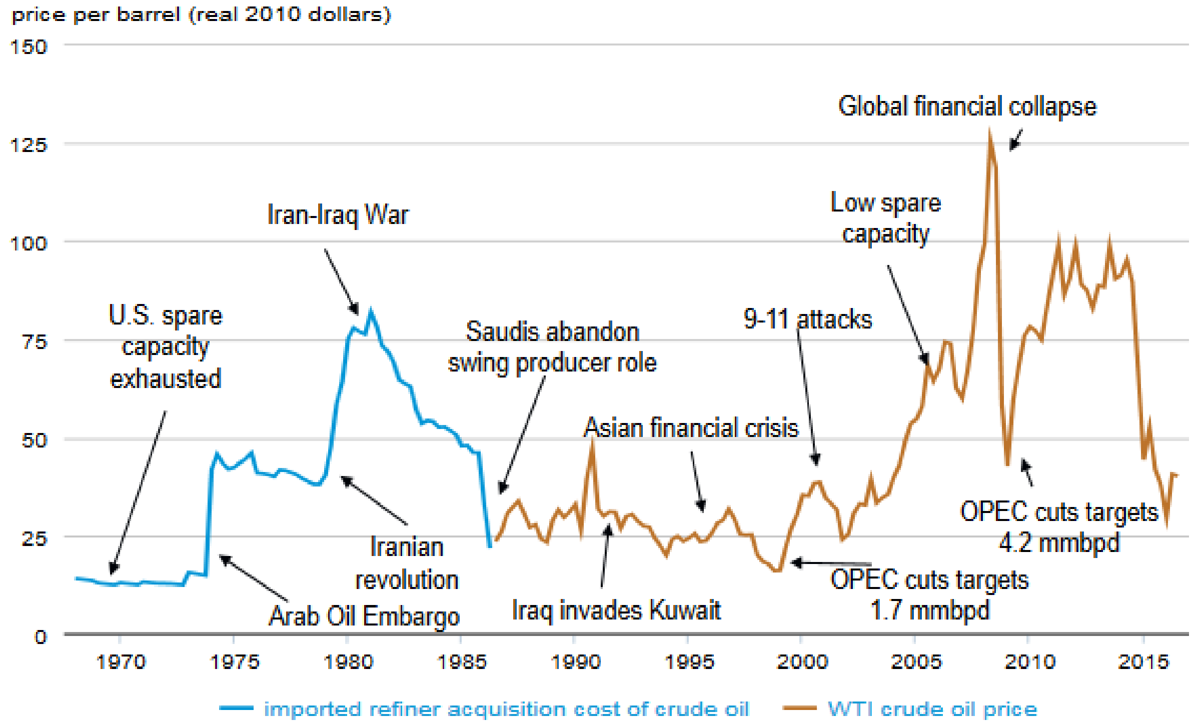
[8] Members of the Organization of the Petroleum Exporting Countries (OPEC): Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Algeria, Libya, Angola, Nigeria, Ecuador, Venezuela, Gabon, Indonesia.

[9] Liquid market is referred to here with a meaning that it is easy to execute a trade at a desirable price, without reducing its price, as there are numerous buyers and sellers. In a liquid market, changes in supply and demand have a relatively small impact on price. Read more: Liquid Market Definition | Investopedia

cargoes under long-term contracts or in spot market[10] transactions; by futures exchanges for the settlement of their financial contracts; by banks and companies for the settlement of derivative instruments such as swap contracts; and by governments for taxation purposes. The most popular physical benchmark oils, often referred to as 'spot' market prices, are as follows.

- *West Texas Intermediate (WTI)*: Quality sweet and light, main reference for the US market (delivery in Cushing/Oklahoma).
- *Brent*: Quality also sweet and light (slightly less than WTI), main reference for North Sea oil.
- *Dubai*: Reference for the Middle East and Far East with higher sulphur content "sour".
- *ASCI*: Argus Sour Crude Index representing the price of medium sour crude oil of the US Gulf coast.

Figure 4: Crude oil prices react to a variety of geopolitical and economic events



Sources: U.S. EIA, Thomson Reuters

Based on BP's report 2016, it is clearly observed that since 1980, when the global oil market developed, prices tend to move together, price differentials exist between the spot prices of these benchmarks because of variations in quality and location. From the mid 1950s to mid 1970s, the oil industry was characterized by dominant international oil companies known as the 'Seven Sisters', they were vertically and horizontally integrated and they controlled the bulk of oil exports from the major oil-producing countries. This industrial structure of the oil market meant that oil trading was more or less an inter-company exchange with no free market operating outside these companies' control. This resulted in an underdeveloped spot market. At the same time, a wave of nationalizations took place in most of Arabic countries and members of OPEC, while appearing new independent companies. Between 1965 and 1973, global demand for oil increased at a fast rate. Most of this increase was met by OPEC which massively increased its production. During this period, OPEC's share in global crude oil production increased from 44% in 1965 to 51% in 1973. At this period, it represented a complete shift in the power of setting the oil price from multinational companies to OPEC. The new system was centered on

[10] *Spot Market* is that in which produce is traded for immediate delivery. It differs from Future Market in which delivery is made at a future date.

the concept of reference with Saudi Arabia's Arabian Light being the chosen marker crude. In the late 1970s with the emergence of new players on the global oil scene, the degree of vertical integration between upstream and downstream considerably weakened, long-term contracts linked to OPEC marker price and producers and governments started selling their crude oil directly to third-party buyers. The decline in oil demand in the mid 1980s caused by a worldwide economic recession and the growth in non-OPEC crude oil production after new discoveries in non-OPEC countries, and thereby the increase in the number and diversity of crude oil producers who were setting their prices in line with market conditions, lead to the way to the current 'market-related' oil pricing system. (Fattouh, 2011)

1.1.2 Oil supply

The oil market is certainly the most prominent among the energy markets. Even though crude oil (or petroleum) has been known and used for thousands of years, it became increasingly important during the second half of the 19th century as a primary energy source and as a raw material for chemical products. The main advantages of oil as an energy carrier compared with other primary energy sources is its high energy density and the ease of handling for storage and transport. Today, crude oil is still the predominant source of energy in the transportation sector and is often taken as a benchmark for the price of energy in general. For actual usage, crude oil is transformed via a refinery process into different petroleum products, called 'Refinery Processing Gains', such as fuel oil or gasoline. When oil is processed through a refinery, the volume can increase because the density becomes lower. Therefore, you can get more barrels out of the refinery than you put into it. Oil production is divided into conventional and unconventional oils. *Conventional oil* is composed of two main streams: crude oil, which comes from the ground and natural gas liquids. These liquids are associated with natural gas. Natural gas liquids can be gas condensate or ethane, propane, butane and pentane. *Unconventional oil* includes extra heavy oils, oil shale or kerogen, oil sands or natural bitumen and light tight oil or shale oil. Very large volumes of petroleum exist in unconventional reservoirs, but their commercial recovery often requires a combination of improved technology and higher product prices. About 90% of the world's known accumulations of extra heavy oil are in Orinoco Oil belt of the Eastern Venezuelan basin. The largest bitumen resource is in western Canada containing over 1,700 billion bbl. In addition, the largest known deposit of oil shale is in the Green River in the western US with an estimated 1.5 trillion bbl. Other important oil shale deposits include those of Australia, Brazil, China, Estonia, Jordan, and Morocco (Society of Petroleum Engineers, 2011). Producing or extracting unconventional oil requires techniques that are usually more costly than conventional oil production and become profitable only if oil prices are sufficiently high. On the contrary, there may still be substantial "learning" effects leading to more efficient production processes. An example is the production of light tight oil, which only recently emerged with substantial production volumes using the same technology as for shale gas production (see gas supply section).

Depending on its origin, oil can be of different quality. The main characteristics are viscosity and sulphur content. Fluid crude oils with low viscosity have a lower specific weight and are called *light* crudes. With increasing viscosity and specific weight the crudes are called *intermediate* and then *heavy*. Lighter crude oils are more valuable, since they yield more marketable products requiring less refinery processing. Crude oil with high sulphur content is called *sour* crude while *sweet* crude has low sulphur content. Sulphur is an undesirable characteristic of petroleum products. Since the high sulphur content causes additional costs in the refinery process, sweet crude oils are priced at a premium.

Much of the shale oil produced in the United States is of high quality. These oils are sweet and some of the lightest in the world. Oil found in the North Sea (Brent), Libya, Nigeria, Malaysia, and Algeria is among the sweetest in the world. On the other end, Mexico, Kuwait, and UAE have lower-quality crude. (Market Realist, Inc., 2013)

To become marketable to consumers, refineries convert crude oil into various products. The refining process in its basic form is a distillation process, where crude oil is heated in a distillation column. Ordered by increasing density, the most important *oil products* are

- *Light distillates*: Liquefied petroleum gases (LPG), naphtha, and gasoline.
- *Middle distillates*: Kerosine, gasoil or heating oil and diesel.
- *Fuel oil.*
- *Others*: lubricating oils, paraffin wax, petroleum coke, bitumen.

Worldwide there are approximately 700 refineries to match the demand for the different oil distillates. Since building new refineries is a complex project involving very large investments, refining capacities react slowly to changes in demand. Owing to the combined production process, the prices of different oil products are usually tightly related to each other and can be expressed in terms of price spreads against crude oil. The lighter and more valuable products have higher spreads against crude oil than the heavier products.

The majority of world's oil producing countries is located in Middle East, where the largest share holds Saudi Arabia, being a net exporter of oil. In North America, United States are the greatest producer of the area and at the same time the world's first producer of the year 2015 (see Figure 5), but in terms of trade of 2014, US is being a net importer of oil. Another worth mentioning oil producing country and net exporter of oil constitutes Russian Federation, whose share accounts for 12.4%, while Europe and Eurasia region accounts for 19.4%. The OPEC member countries are oil exporting countries which control over 40% of the world's oil production and over 70% of all known conventional oil proved reserves (BP, 2016). However, non-OPEC production accounts for about 60% of global oil supply at the moment. The larger crude oil exporters of 2015 are the Middle Eastern countries, Russia and West African countries, namely Nigeria, Angola, and Algeria. The larger exporters of oil products in 2015 are United States, Russia, Middle East and Europe. (British Petroleum, 2016)

An indication of the future production potential can be given by the *reserves-to-production ratio* describing the number of years that known reserves are estimated to last at the current rate of production. Venezuela is a country which holds the largest amount of proved oil reserves accounting for 300.9 billion barrels in 2015, whereas its production is relatively low and it has declined since 2005 (see Table 3). Venezuela holds the tenth world position in terms of production (Figure 5). Venezuela's production at current levels will continue for 314 years. On a regional basis, South & Central American reserves have the highest R/P ratio, 117 years (BP, 2016). Although, U.S. holds only 55 billion barrels in terms of proved oil reserves being at ninth position, they have the largest oil production globally, which is going to last almost 12 years at current production levels. Saudi Arabia being second in proved oil reserves, its production is large and is going to last 61 years. For OPEC members the reserves-to-production ratio was 86.8 years, whereas for non-OPEC countries the ratio was only 24.9 years (see BP, 2016). However, this indication may be misleading due to changes in production, revised estimates for existing reserves and discoveries of new reserves.

In the oil and gas sector, National Oil Companies often called "NOCs" dominate in countries where either oil production or consumption constitutes significant share of their domestic economy. In those countries, there are inevitably strong incentives for comprehensive state involvement or even direct state control to secure political and financial advantages. Petroleum is frequently portrayed as a "strategic" industry that can be used and abused as an economic or political weapon. (Silvana Tordo, 2011) Hence, it is "too important to be left to the market"[11]. Although prior to the crisis of 1973, private international oil companies called "Seven Sisters" used to be seven powerful companies, today most of the largest oil companies are state-owned holding the majority of oil and gas reserves. The 73% of world oil reserves (as of October 2009) and 61% of world oil production (2008) are controlled by NOCs. NOCs also control 68% of world gas reserves (as of October 2009) and 52% of world gas production (2008).[12] The largest IOCs today are ExxonMobil, Royal Dutch Shell, Total, BP, and Chevron[13]. The largest NOCs today are Saudi Aramco (Saudi Arabia), Rosneft/Gazprom (Russia), NIOC (Iran), Petrochina (China), PDVSA (Venezuela), Statoil (Norway), Petrobras (Brazil)[14].

Many scholars and studies (Colgan, 2014) argue that there are some tendencies that are recurring almost in all oil producing states, often called petrostates[15]. These tendencies are driven by common incentives generated from oil income. One of the best-known traits of petrostates is that they suffer from the "resource curse", which is rather a collection of negative economic and political phenomena[16]; each of the symptoms and causal mechanisms linking oil to these effects are much debated by scholars. The general characteristics of oil exporting states are following mentioned. They engage in about 50% more international conflict and they are at higher risk of civil wars and domestic strive. Their economic growth is weaker than it ought to be given the vast potential of their natural resources, and more volatile than in non-petrostates. They are more likely to be corrupt with a significant improvement in civil liberties (Rabah Arezki, 2009) and their governments' fiscal policy is based in wasted public spending, low tax rates, providing a rich variety of public goods. Petrostate governments' are more likely to provide energy subsidies and in a larger magnitude. Most scholars agree that the above mentioned rentier politics are partially responsible for lower levels of democracy (Colgan, 2014) (Tsui, 2011) (Ross, 2011). Not only petrostates share similarities in domestic politics but also there are common behaviors in foreign policy (Colgan, 2014).

A vast body of literature, some of them are (Ross, 2012) (Colgan, 2014) (Jeffrey D. Sachs, 2001) (Ploeg, 2007), confirms that economic resource curse exists; there is a negative effect of resource abundance on the rate of economic growth. Empirical cross-country evidence shows that resource rich countries grow more slowly than resource poor ones (Jeffrey D. Sachs, 2001). However, there are skeptics (Acemoglu, 2008) (Stephen Haber, 2011) of the political resource curse; specifically they find a positive relationship between natural resources and democracy. Their research finds that increases in resource reliance are not associated with authoritarianism.

Furthermore, recent studies (Ploeg, 2007) have shown that natural resource abundance may also undermine the quality of institutions. A resource boom reinforces rent grabbing, especially if institutions of the country are bad, and keeps in place bad policies. Finally, countries such as

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[11] Quote which is ascribed to Sheikh Ahmed Yamani, Saudi oil minister from 1962–1986.

[12] Presentation of Mark Thurber, Program on Energy and Sustainable Development, Stanford University - See more at: https://www.chathamhouse.org/events/view/180397#sthash.vRWXZkTi.dpuf

[13] http://www.tharawat-magazine.com/facts/top-10-biggest-oil-gas-companies/#gs.5yCHr6k

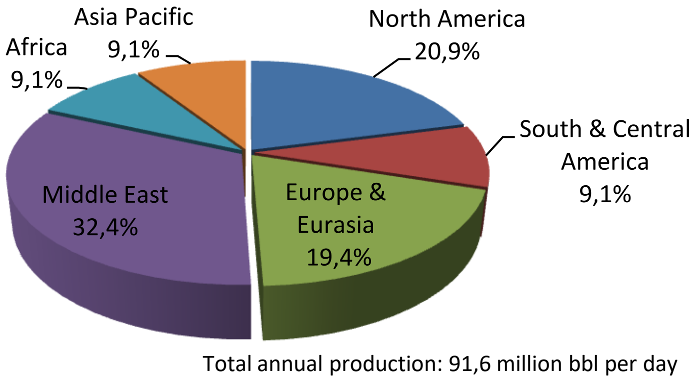
[14] The 25 Biggest Oil And Gas Companies In The World, Forbes list 2016

[15] 'Petrostate' mean any country that has annual net export revenue of at least 10% of its Gross Domestic Product (GDP). Examples include Saudi Arabia, Iraq, Iran, Russia, Norway, Venezuela, Ecuador, Nigeria, Angola, Algeria, Libya, and Sudan. Exception is Norway which enjoys a high level of political and economic development.

[16] The economic and political definition can be found (Colgan, 2014)

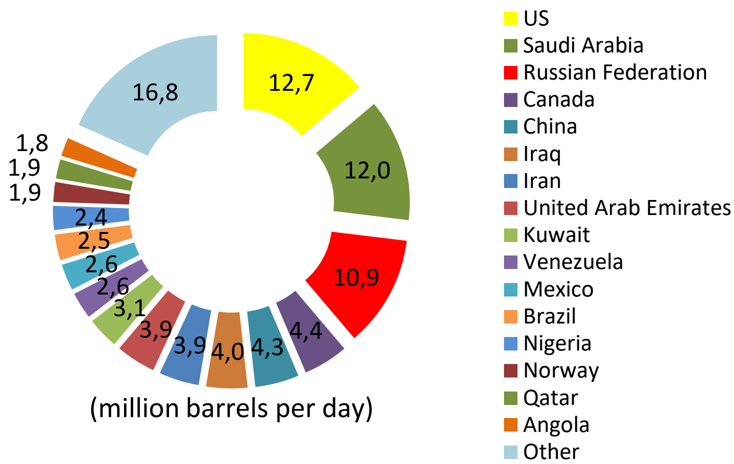
Botswana, Canada, Australia and Norway suggest it is possible to escape the negative effects of resource curse. Thus, practical suggestions for a better management of natural resources are needed.

Figure 5: World oil production of 2015 by region.



Source: BP (2016)

Figure 6: Crude oil production by country 2015.



Source: BP (2016)

Table 3: Crude oil reserves - Top 8 countries.

	Reserves (billion bbl)		Production (Kb/d)		R/P
Country	**2015**	**2005**	**2015**	**2005**	**years**
Venezuela	300,9	80,0	2.626	3.308	314
Saudi Arabia	266,6	264,2	12.014	10.931	61
Canada	172,2	180,0	4.385	3.041	108
Iran	157,8	137,5	3.920	4.216	110
Iraq	143,1	115,0	4.031	1.833	97
Russian Federation	102,4	104,4	10.980	9.597	25,5
Kuwait	101,5	101,5	3.096	2.668	90
United Arab Emirates	97,8	97,8	3.902	2.919	69
Rest of the World	355,3	294,0	46.716	43.383	-
Grand Total	**1697,6**	**1374,4**	**91.670**	**81.896**	**50,7**

Source: BP (2016)

1.1.3 Gas and LNG Prices

Compared to oil, the natural gas market is more regional due to the higher costs of gas transportation; there is no single international gas price. Globally, the price of LNG is benchmarked against competing fuels, mainly pipeline gas, coal and fuel-oil. There are three separate and relatively independent regional markets; North American, European and East Asian. In the US, LNG competes with pipeline natural gas and is benchmarked against the Henry Hub (HH) price, a physical hub, for domestic spot and short-term transactions. In Europe, the LNG price is benchmarked against fuel oil and natural gas spot prices (NBP or import price in Germany). LNG price in Asia is benchmarked against the average monthly price of crude oil imported in to Japan. This benchmark is known as Japan Crude Cocktail (JCC). (Vivoda, 2014)

However, due to the "shale gas boom" in the USA and increasing demand in Asia, the price differentials between gas prices in North America, Europe and Asia-Pacific have widened considerably, starting in 2008 (see Figure 8). The shale gas boom leaded to fall in the natural gas price in United States, whereas the price of gas in Japan has increased substantially, especially after 2010 and in 2011 because of the Fukushima accident. In Europe, the price has remained more or less, at a medium level, but the price on the National Balancing Point[17] (NBP), which is a competitive market, has been significantly lower than the import price in Germany, at least until 2013.

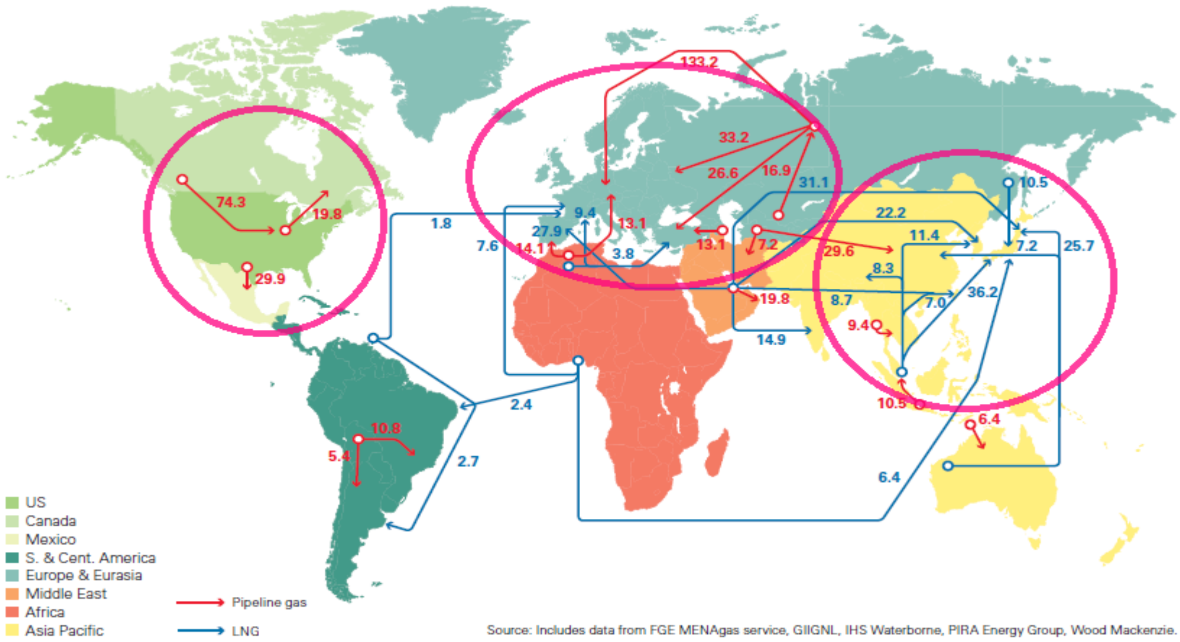
Historically, those three segmented markets have had little interaction, since LNG played a significant role only for the Asian market (Figure 7). Owing to a growing LNG infrastructure, market interaction has increased significantly during recent years. Figure 7 shows the trade movements of gas in 2015 either through pipelines or LNG. The *North American market* is essentially self-confined and gas is traded mainly through pipelines. Until now, the USA does not trade with the rest of the world[18] except movements to and from Canada and trade in between United States and Mexico. Although most of the natural gas consumed in the United States is produced domestically, the United States is a net importer of natural gas, but at the same time almost self sufficient producer. The shale gas boom in the mid-2000s filled the gap which was created by the declining conventional domestic gas production. The US wholesale market for natural gas is liberalized and competitive. *The Far East market* which is essentially an LNG market; it receives gas from various origins within the region itself or from the Middle East and some from Africa. Vast distances between major regional producers, often make it prohibitively expensive to build gas pipelines across Asia. The structure of domestic natural gas markets in Asia limits competition due to state intervention in supply chain and preference for regulated monopolies that deliver LNG under long-term oil-indexed contracts, which remained the industry's predominant pricing mechanism since 1970s and 1980s. Since 2010 and after the March 2011 Fukushima disaster, the continued prevalence of oil-indexation has had the most adverse effect on Asian importers, especially Japan, the world's largest LNG importer. Due to the increased demand, Asian importers were exposed in high prices and increased transaction costs. Nevertheless, natural gas in Asia is beginning to be traded under short-term contracts that more closely reflect international natural gas supply and demand balances. (Vivoda, 2014) The *European gas market* is essentially a pipeline gas market[19]. The gas market in the EU is characterized by gradually declining domestic consumption and more rapidly domestic production. The main exporters to serve the Western European demand are Russia, Norway,

[17] NBP is not a physical point; it is a virtual point, the balancing point of all gas flows in the United Kingdom.
[18] In 2015, 93% of U.S. net imports of natural gas came by pipeline, and 7% came in LNG ships from around the world.
[19] In 2015, of the EU gas imports, 80-85% delivered through pipelines, the remaining 15-20% in the form of LNG.

the Netherlands and Algeria primarily by pipeline. In addition, the European market imports natural gas via LNG from Qatar and Nigeria. The UK gas market was liberalized in 1996, and the National Balancing Point (NBP) gained acceptance as a universal delivery point and "trading hub" in the UK. The natural gas market in Continental Europe was for a long time still dominated by long-term supply contracts indexed to oil prices. Fragmented market zones did not attract sufficient liquidity for a competitive wholesale gas market independent of oil-indexed supply contracts. In the second half of the 2000s, European energy regulation and competition law created increasing momentum towards effective third party access. Furthermore, a series of events during the period 2008-2012, such as the increase in crude oil prices above $100/bbl, changed significantly the market fundamentals (Stern, 2013). Competitive conditions created and the emergence of "hubs" created more transparency in prices, yet to Russia's resistance to the negotiations, the oil-linked long term contracts have not disappeared. Meanwhile, the liquidity of gas trading hubs has increased also in Continental Europe and moving more towards a market-based gas pricing or gas-on-gas competition. The most important natural gas hubs for trading in Europe are:

- National Balancing Point (NBP) in the UK;
- Title Transfer Facility (TTF) in the Netherlands;
- Zeebrugge Hub (ZEE) in Belgium;
- NetConnect Germany (NCG);
- Gaspool Hub (GPL) in Germany.

Figure 7: Major gas trade flows worldwide 2015 (bcm).



Source: BP 2016

Figure 8: **Global natural gas prices (USD/mmBtu).**

Source: BP Statistical Review of the World Energy 2016

1.1.4 Natural Gas Supply

Natural gas is one of the most important primary energy sources. It consists mainly of methane (CH4), at least 75% in volume, which is the shortest and lightest in the family of hydrocarbon molecules. Other components are heavier hydrocarbons such as ethane, propane and butane and contaminants such as sulphur. Natural gas and oil are often found in the same deposits. Depending on which of the two dominates, it is called either a natural gas or oil field. Hence, natural gas can be "associated" gas (found in oil fields), or "non-associated" gas (isolated in natural gas fields). Unlike oil, because of its low density, gas is difficult to store and transport. In the past, gas found as a by-product in oil fields was therefore simply burned without any economic use. However, today liquefied natural gas (LNG) provides, in many cases, a cost-effective solution for the gas to be financially viable to transport to the market. The alternative way to be transported is via pipeline.

The natural gas industry is extracting an increasing quantity of gas, with a growing role in the future, from challenging (unconventional) resource types: *tight gas formations*, *coalbed methane*, *shale gas*, and *gas hydrates*. According to IEA (IEA, 2013), unconventional gas production made up almost 13% of global gas supply in 2009, this share is going to increase in the future (over 20% by 2035). Figure 9 illustrates where the various gas resource types can be found under the ground. Extracting tight gas and shale gas requires hydraulic fracturing, while coal bed methane is gas extracted from coal beds, with significant reserves being in the USA, Canada and Australia. More than 40 countries have evaluated the potential of coal bed methane. The US has the most mature production, with commercial production starting in the 1980s. Tight gas and coal bed methane have been produced for many decades; the extraction of shale gas is technologically more intricate and began to become profitable only at the beginning of the 21st century. Since then a "shale gas boom" has emerged in the USA, able to overcompensate declining conventional gas production and leading to decreased gas prices in the USA. Shale gas production has also developed in Canada and China. Last but not least, gas hydrates are thought to represent an important future source of natural gas. They bind immense amounts of methane within seafloor and Arctic sediments. Gas hydrates are included in unconventional resources, but the technology to support commercial production has yet to be developed. Estimates for gas hydrates vary widely between 60,000 and 700,000 (Tscf) trillions of standard gas cubic feet. The Mackenzie River delta in northern Canada contains some of the most concentrated deposits. A number of other countries such as Russia, the US, India, Japan, and China also have substantial marine gas-hydrate deposits. (Society of Petroleum Engineers, 2011)

Figure 10 shows the provenance of gas of year 2012, from which region it is produced and also to what extent it is traded internationally, across regions. Almost 90% of the total world gas production is composed of conventional gas, the rest being non conventional. The marketed production represents the gas trading. In 2012, the world production was 3,380.2 bcm. The 70% of the total gas marketed production was consumed regionally, while the rest 30% was traded internationally. Most of the gas is consumed in the same region where it is produced, because of the cost of transportation and storage. Hence, an oil and gas producing country will prefer to exploit gas for its domestic usage and export the oil.

Europe, Eurasia and North America regions hold the largest shares of the world's production (Figure 11). The major gas producing countries are not countries which hold the largest reserves. Almost 60% of the world's total proven gas reserves are concentrated in four countries (Iran, Russian Federation, Qatar, and Turkmenistan). On the contrary, the countries with the highest gas production are the United States and Russian Federation (767.3 and 573.3 bcm respectively in 2015), followed by Iran, Qatar and Canada (between 190 bcm and 160 bcm) and China, Norway, Saudi Arabia with around 120 bcm in 2015. Russia has a long history as a natural gas supplier to Western Europe and the reserves are well connected via pipelines. The large reserves in the Middle East (see Figure 3), however, could not be utilized fully in the past since efficient transportation to consumers was not available. Over the last decade a growing infrastructure for LNG has been established, allowing suppliers to transport increasing volumes of natural gas between continents, leading to increased export volumes from the Middle East (e.g., Qatar). The countries with the largest gas reserves are shown in Table 4. It can be easily observed that US has a low R/P ratio, only 14 years. For OECD members, the reserves-to-production ratio is only 15 years as of 2015, whereas for non-OECD countries the ratio is 74 years. On a regional basis (BP, 2016), Middle East reserves have the highest R/P ratio exceeding the 120 years. The ratio is also very high in Africa (66 years) and in Eurasia (57 years). In North America there is large developed gas production, in fact US is the first world gas producer, as this has been also the case for oil. The high levels of production of the United States can be explained by the existence of a developed gas market. Nevertheless, the R/P ratio in North America is small, only 13 years. That is not because there is a lack of gas in North America; it is simply because there are no incentives in exploring for gas. At the moment, the prices for gas in North America are low. Thus, producers do not have a lot of incentives for gas exploration.

Figure 9: Schematic geology of natural gas resources

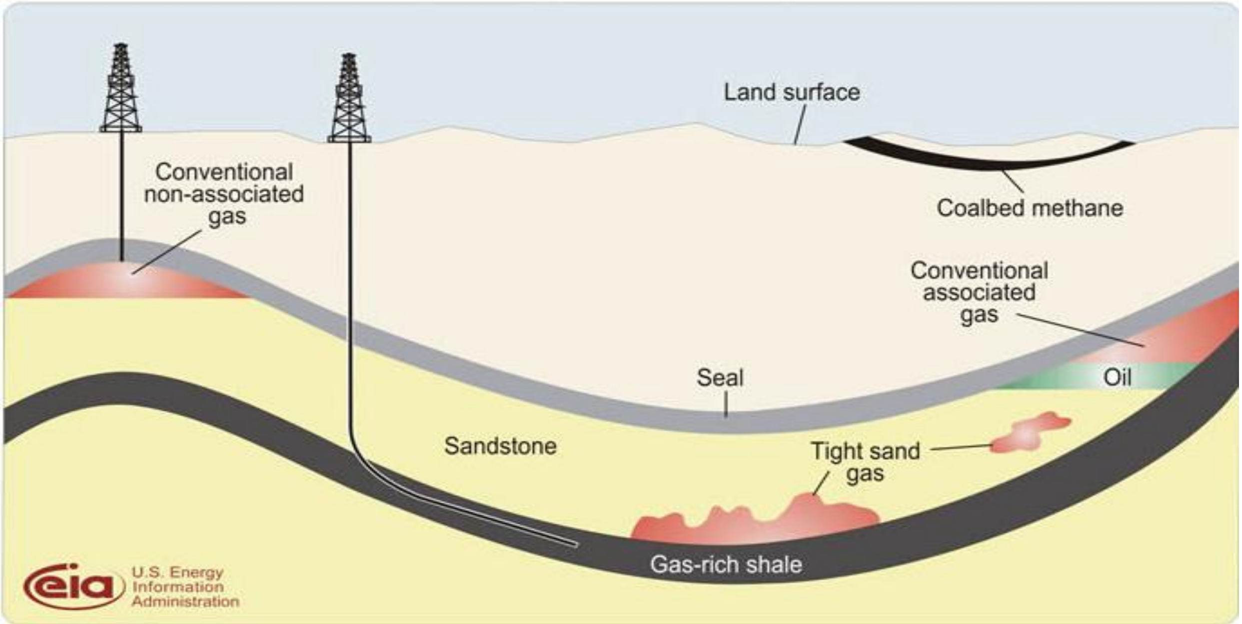
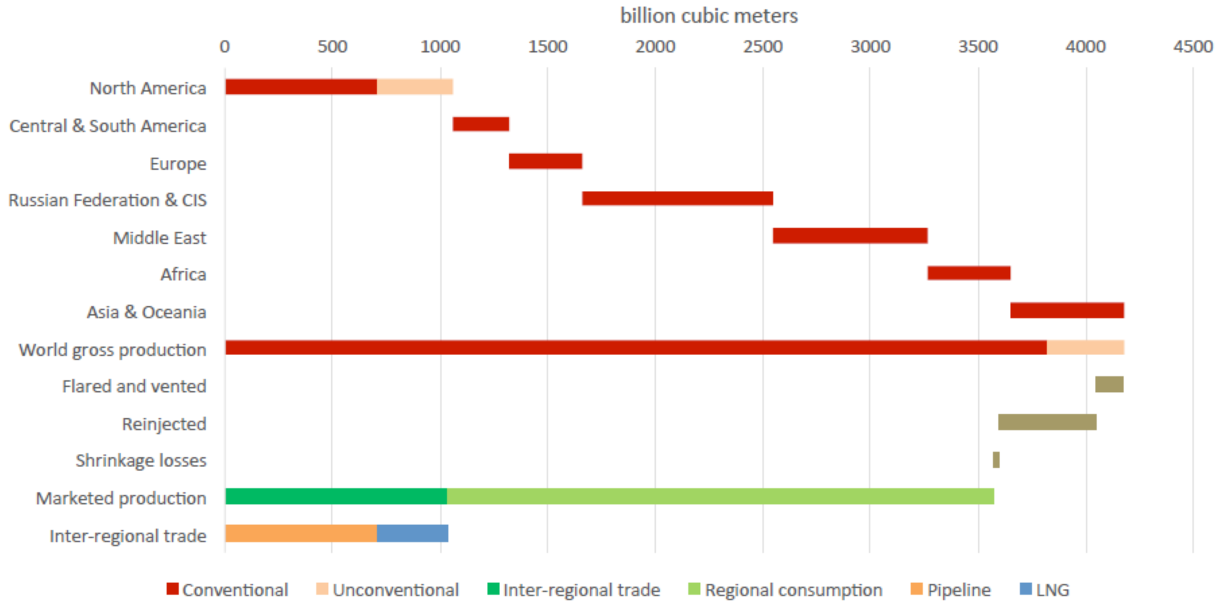
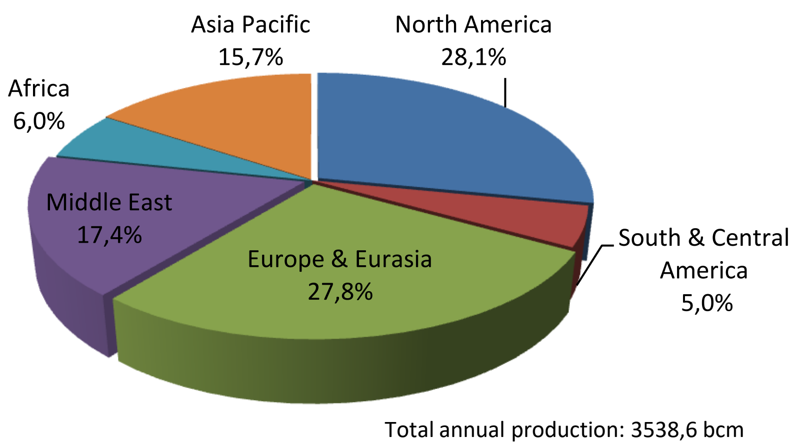


Figure 10: Estimated worldwide natural gas flows (2012).



Source: EIA International Energy Statistics

Figure 11: World gas production by region 2015



Source: BP 2016

Table 4: **Natural gas reserves - Top 8 countries.**

	Reserves (tcm)		Production (bcm)		R/P
Country	2015	2005	2015	2005	years
Iran	34,0	27,6	192,5	102,3	177
Russian Federation	32,3	31,2	573,3	580,1	56
Qatar	24,5	25,6	181,4	45,8	135
Turkmenistan	17,5	2,3	72,4	57,0	241
U.S.	10,4	5,8	767,3	511,1	14
Saudi Arabia	8,3	6,8	106,4	71,2	78
United Arab Emirates	6,1	6,1	55,8	47,8	109
Venezuela	5,6	4,3	32,4	27,4	173
Rest of the World	48,2	47,6	1.557,1	1.348,2	-
Total World	**186,9**	**157,3**	**3.538,6**	**2.790,9**	**52,8**

Source: BP (2016)

1.1.5 Geopolitics[20] of natural gas

Natural gas is considered a politicized commodity. Owning to the fact that trading of natural gas via pipeline always requires interconnected land infrastructure, which is capital intensive, often resulting in being combined with long-term intergovernmental agreements. LNG gains a significant advantage as an alternative means of natural gas transportation. Since LNG can change destination, it is considered more flexible. There is historical evidence[21], when governments tried to affect the natural gas flow with ultimate goal to acquire greater geopolitical power. (Nikitakos, 2013) Disadvantage constitutes the fact that consuming countries are dependent on pipeline imports from only one supplier and gas suppliers are dependent on transit countries from which the pipeline is passing. In any transit of oil and gas pipeline there is a tendency to generate conflict and disagreement, often resulting in bad political relations between neighboring countries. A number of academic studies have elaborated on different aspects of the relationship of mutual influence that exists between the natural gas business and politics. (Silvia Colombo, 2016) The perception of natural gas as a political tool (e.g. interruption of supplies as political pressure) is widely understood. The fusion of state and company interests, and the fact that NOCs control the majority of conventional gas reserves and production, also contributes to the image of gas as a politicized commodity. Moreover, similar to oil, gas is often perceived as contributing to resource curse dynamics and rent-seeking behaviors, and to concentrating money and power in the hands of elites. (Silvia Colombo, 2016)

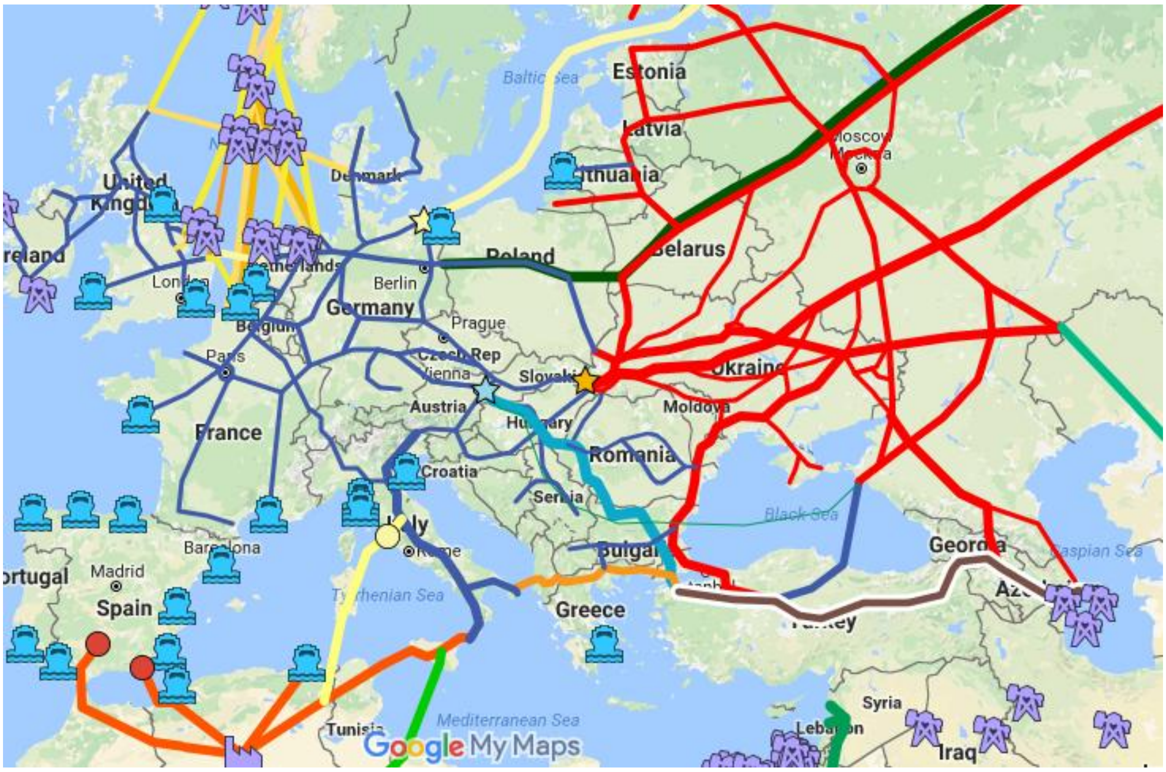
A recent striking example of the transit pipelines as a source of conflict constitutes the gas export of Russia to Western Europe. The major gas pipeline system was laid under the former Soviet Union. An intergraded system was built which collected gas from the producing fields in Western Ural, brought it towards major population centers in Soviet Union itself, notably Kiev, and then converged towards an export point in Ukraine, called Uzhgorod, where major storage capacity existed. This well-planned system which brought gas from Western Ural to European markets; Austria, Italy, Germany, France, worked over decades until the point when the Soviet Union collapses. Pieces of pipelines in different countries are the ownership of newly

[20] Roughly speaking, geopolitics covers the relationship between territory and/or geography and the pursuit of power at the state level. More definitions about geopolitics at http://www.clingendaelenergy.com/inc/upload/files/Geopolitics_and_Natural_Gas_Draft_Report_2.pdf, page 10.

[21] Examples constitute the Ukrainian crises of 2006 and 2009.

independent countries. The key point was that all Russian gas exports towards Western Europe were passing through Ukraine which found itself in a strong bargaining position. During the 1990s, problems began to emerge between Russia and Ukraine over the terms of gas transit; particularly they were related to lack of payments by Ukraine for gas lifted from the transit line. Finally, following the Orange Revolution, the political relations between Ukraine and Russia deteriorated, leading to cut offs in supplies on January 2006 and later again on January 2009. LNG supplies proved to be a valuable alternative to pipeline gas imports. On the one hand, after these crises security of gas supply moved very rapidly up the EU agenda, EU is trying to reduce its dependence on Russian supplies, still being its major gas supplier, by finding alternative sources of supply. On the other hand, Russian Federation is seeking alternatives to Ukraine, building pipelines that would bypass the country. Despite the efforts of Russia to gain independence from Ukraine, notably some of the projects were Yamal-Europe, Blue Stream, Nord Stream; they are still at least 40% dependent on transit across Ukraine for the exports to Western Europe. (Luciani, 2016)

Figure 12: **Existing and projected pipeline system of natural gas.**



Source: (Luciani, 2016)

1.1.6 Liquefied Natural Gas[22] (LNG) supply

The LNG value chain, after gas extraction, consists of a processing plant, which consists of one or more liquefaction units (called LNG trains), where it is cleaned from impurities and then liquefied; a fleet of special insulated LNG carriers and a regasification terminal, where the LNG is unloaded, regasified and injected into pipelines by which it is distributed to the end-users. Liquefaction process gives rise to the largest costs in the LNG value chain. Besides land-based terminals, regasification units can be built on board an LNG carrier (storage and regasification vessel). The infrastructure needed for production, transport and regasification is capital

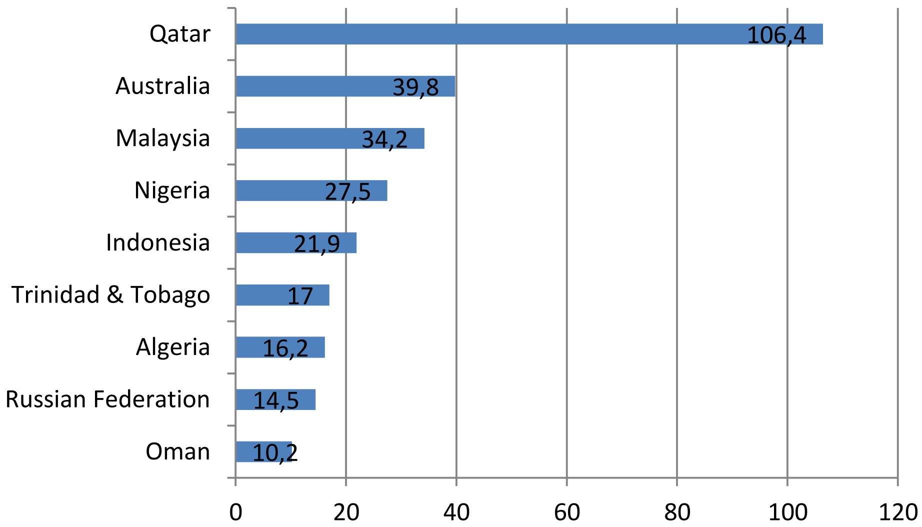
[22] LNG is natural gas which has been liquefied by cooling it to a temperature of approximately minus 160°C. The density is thereby increased 600 times. This volume reduction permits cost effective storage and transportation of LNG over long distances.

intensive and it may cost far more than importing natural gas via existing pipelines, especially if it requires the construction of new infrastructure. Consequently, LNG has traditionally played a major role only in countries where pipelines are not available, such as Japan, South Korea or Taiwan (main LNG consumers).

The main exporters for LNG are shown in Figure 13. The total LNG exports in 2015 amounted to 338.3 bcm, marking a historical high in the industry's history and rising above the previous high of 330.8 bcm in 2011. The increased demand of 2011 originated from Japan due to the Fukushima accident. Qatar exported nearly one-third of global trade, and remains for a decade now the world's largest LNG exporter. For the first time ever, Australia overtook Malaysia to become the second largest exporter in the world. Only 17 countries exported LNG in 2015, down from 19 in 2014. This is owing to the suspension in exports from Angola and Egypt, which were shut down for repair work and feedstock loss, respectively. Nevertheless, several new plants started up in 2015 which helped to increase the total LNG trade by 6 bcm from 2014 to 2015. (International Gas Union, 2016)

Finally, it should be noted that political concerns are particularly related to pipeline gas trade. Thanks to its destination flexibility and lesser exposure to transit risks, LNG is a dynamic factor in gas markets and is seen as a potential contributor to the de-politicization of gas trade. The share of LNG in total gas trade has been growing rapidly, particularly in the last 15 years, and more and more players are participating in the LNG market, contributing to increasing its levels of liquidity. (Silvia Colombo, 2016)

Figure 13: Largest LNG-exporting countries 2015.



Source: BP (2016).

1.2 Global Demand

Oil and natural gas demand moving in parallel with global primary energy consumption, which is affected by changes in economic activity, demographic, structural trends in every country's industry, legislation for improvements in energy efficiency (reductions in energy intensity), policy measures and environmental developments such as the global climate change mitigation agreement (COP21).

In the Europe and North America, primary energy consumption is observed in recent years with a slower growth in relation to the past reflecting modest economic growth and some of the aforementioned changes.

1.2.1 Oil Demand

According to data of IEA's excerpt from oil information of 2016, the world energy balance show that oil remained the most used fuel in the world energy mix in 2014 and its share did not decrease (31.3%). In fact IEA's excerpt refers that in 2014, world oil demand increased by 1.4% from 2013. World Bank's Commodity Markets Outlook of April 2016 remarks that world oil demand grew more in 2015, by 2.0%, marking the highest growth in five years, aided by low prices (The World Bank Group, 2016). Historically, oil demand originated from OECD countries, but over the last decades the share of Non-OECD countries increased to nearly 50% and over the last years non-OECD oil consumption is overtaking OECD consumption, largely driven by increased demand from developing countries along with economic growth, especially from China and India. Non-OECD countries represent the largest share of the world oil demand (52% in 2014). There are now indications that the oil demand in the industrialized world has past its peak and is in the decline phase. The average growth rate of demand was -0.7% between 2000 and 2009 in the OECD region, as opposed to a growth of 3.5% in the rest of the world (excluding the Former Soviet Union countries) (Bhattacharyya, 2011). In 2014, OECD oil demand contracted by 1.6% from 2013, pulled down by the decline in road transport and power demand in Japan, whereas Non-OECD oil demand increased by 2.0%, surpassing OECD demand by more than 152 million tones. On the contrary, in 2015, OECD demand returned to grow for the first time in five years (+0.7%), while oil demand in Non-OECD continued growing (+2.9%) (International Energy Agency, 2015).

Non-OECD countries accounted for all the increase in the global energy use in 2014, because several factors reduced collective consumption in OECD countries from the peak reached in 2007. These factors were demographic and structural economic trends, mandatory energy efficiency (see note in page 5 for definition) regulation, reduction of fossil-fuel subsidies and switching to alternative fuels. (International Enegy Agency, 2015) These structural economic trends are observed since the 1970s, by recording modest income and slower GDP growth in these countries, together with a structural transition away from more energy-intensive manufacturing industries towards service sectors.

On the one hand, rising oil consumption reflects rapid economic growth in non-OECD countries. Developing countries tend to have a greater proportion of their economies in manufacturing industries, which are more energy intensive than service industries. Many non-OECD countries are also experiencing rapid growth in population with rising incomes, which is an additional factor supporting strong oil consumption growth. Figure 14 points out the strong relationship between GDP growth rates and growth in oil consumption in non-OECD countries during the years 2001-2016. Increased demand pressure due to economic growth overwhelmed any downward pressure on oil consumption due to higher prices. (U.S. Energy Information Administration, n.d.) Hence, it is self evident that global oil demand is heavily influenced by economic growth, since developing countries of Non-OECD caused the increase of global oil consumption growth in recent years. China's strong economic growth has recently resulted in becoming the largest energy consumer and second largest oil consumer in the world. On the other hand, structural conditions in economies of OECD countries resulted in relatively slower economic growth and lower oil consumption in recent years. Developed countries tend to have larger service sectors relative to manufacturing. As a result, strong economic growth in these countries may not have the same impact on oil consumption as it would in non-OECD countries. Also, the impact of prices on OECD consumption is more evident than for non-OECD countries;

from 2006 to 2009 after prices rose, oil consumption in OECD countries fell. (U.S. Energy Information Administration, n.d.)

The main driver for oil demand is the transport sector, accounting for 64.5% of the overall oil consumption in 2014[23]. Road transportation is the biggest contributor to global oil demand being followed by aviation and marine bunkers sector[24]. Transportation holds the largest share in oil consumption over the decades. Other drivers for oil demand include the residential, industry and power generation sectors. The sectors which have been more flexible (industry, electricity generation), meaning that it is possible to substitute oil, they have reduced their share of oil usage. Transportation, on the other hand, which is less flexible, dominates more than ever.

The main world's oil demand comes from Asia Pacific, North America and Europe and Eurasia (see Figure 15). The countries with the highest oil consumption at the end of year 2015 are United States and China, with shares 19.7% and 12.9% of the total global consumption, followed by India, Japan and Saudi Arabia contributing 4.5%, 4.4% and 3.9% respectively. In addition, it is worth to mention that India, China and Saudi Arabia, marking 8.1%, 6.3% and 5.0% growth over the previous year (2014), had the largest oil demand growth among the five first world's oil consumers. (British Petroleum, 2016) As far as crude oil imports are concerned, Europe, United States, and China hold the greatest world's share of 2015. By country, the United States has historically been the largest importer of crude oil, followed by China. (British Petroleum, 2016) If this is combined with crude oil imports and oil product exports represented in the previous subsection (see oil supply), it becomes apparent that United States import crude oil in order to satisfy their needs, but a significant amount is refined and exported as oil products.

As a consequence of the regional demand and supply imbalances (see Fig. 5 and 15) the trade volume has been growing over time. While Europe and North America (mainly the USA) remain major importers, the growth in trade since 1990 is originating from the other areas (mainly Asia Pacific). The level of oil import has more than doubled in this region between 1990 and 2009. (Bhattacharyya, 2011)

Oil remains the dominant fuel in the global energy mix. After the oil shocks of 1973 (its share in the global energy demand was 48%) and 1979, there was a shift away from oil. Efforts for the decrease in oil dependence resulted in the exploitation of alternative fuels such as coal, natural gas, nuclear, biofuels and renewable energies and conservation measures increased energy efficiency. However, based on data from IEA Statistics (2006, 2016), oil share as of 2004 was 42.3% of the total final consumption, while its share in 2014 was 39.9%, that is only a decrease of 2.4% in the last decade. Oil share has been losing ground nevertheless it remains the most important source of energy and the world is still dependent on the use of oil as a fuel. Oil dependency can be measured in various ways, for example as oil-GDP ratios, or as net oil imports in relation to exports. The degree of import dependency varies greatly across the globe. Measures indicate that OECD countries are now less dependent on oil, because of their diminishing oil intensity[25]. (International Energy Agency, 2015) The higher the oil intensity of GDP, the more vulnerable the economy will be to oil price increases. Countries with a high oil-GDP ratio will suffer the most in this respect.

[23] Key world energy statistics 2016, IEA, page 33.
[24] OPEC Energy Review December 2015
[25] Oil intensity of economic activity: Measures the amount of oil used to generate a unit of economic output. In practice, this is done by dividing oil consumption by Gross Domestic Product (GDP).

1.2.2 Natural gas, LNG demand

IEA's Key World Energy Statistics Report indicates that natural gas has a stable share of around 15% over the years in the global energy consumption. IEA's excerpt from natural gas information of 2016 refers that in 2015, global demand for natural gas showed an increase year-on-year of 1.4%, recovering from the small decrease observed in 2014 (-0.7%). IEA's excerpt of 2015 points out that in 2014, OECD natural gas demand fell by 2.3% from 2013, mainly due to the exceptionally mild winter in Europe and despite the cold winter in the United States. On the contrary, Non-OECD demand for natural gas of 2014 increased by 0.7%, surpassing OECD demand. As the same has been the case for oil, natural gas demand came from developing countries, in particular the OECD countries over the years, notably in 1965 their share was 75% of the global gas demand. In recent years, non-OECD natural gas consumption surpassed OECD gas consumption, contributing 53.5% and 46.5% respectively. (British Petroleum, 2016)

The majority of the world's natural gas demand, alongside with imports, originates from Europe and Eurasia, North America and Asia Pacific (Figure 16). In contrast to oil, natural gas consumption is more regional; the natural gas producing regions are also the ones who consume it (comparing Fig. 10, 11 and 16). United States (22.8%), Russian Federation (11.2%) and China (5.7%) are the world's top three gas consumers at the end of 2015, followed by Iran (5.5%), Japan (3.3%) and Saudi Arabia (3.1%). (British Petroleum, 2016) It is noteworthy to mention that Russia and Japan decreased by 5.0% and 3.9% their natural gas consumption over the previous year, while Iran and China registered substantial growth in natural gas consumption among the top six world gas consumers, accounting for 6.2% and 4.7% respectively. (British Petroleum, 2016) Japan decreased its LNG imports mainly due to returning nuclear capacity (Japan) and the continued deployment of power generation sources other than gas.

Natural gas is primarily used as a fuel for electricity generation, industrial, residential and commercial sectors, mostly for domestic heating. The power sector is by far the largest user of natural gas with around 40% of global gas demand. Industrials use roughly 24% of total gas consumption and the residential/commercial sector 22%[26]. However, the Pacific region (Japan) is the leader in this area with a share of 55% of its gas supply being used in the power sector, whereas the share is close to 30% in North America and in Europe. (Bhattacharyya, 2011) Over the past six years, electricity demand in United States has remained flat while gross domestic product (GDP) has increased by 6%. Moreover, since 2008/2009 financial crisis, European GDP and manufacturing and industrial gas usage does not follow the same growth path (between 90s and 2000s GDP and industrial production grew at a similar pace). (International Energy Agency, 2015) This indicates a decoupling between economic and gas-intensive sectors growth in both developed economies.

In terms of trade, natural gas is mainly transported via pipeline as evidenced by trade movements according to BP (British Petroleum, 2016). Global LNG trade accounted for one third of the world natural gas trade in 2015. Total volumes of natural gas transported by pipeline reached 704.1 bcm in 2015, whereas total volumes of natural gas transported in liquefied form were 338.3 bcm. (British Petroleum, 2016) LNG trade increased only 1.8% from 2014 to 2015, while natural gas pipeline trade expanded the same period by almost 4%.

Most of the world producers consume the majority of their output domestically; only Norway has a low domestic demand. This leaves a handful of major gas producers with exportable gas—

[26] https://www.iea.org/about/faqs/naturalgas/, access on 20.11.2016.

notably Qatar and Algeria. Although, the US domestic gas supply yet insufficient to meet its own needs, their demand and supply balance is almost equal. In terms of regional supply–demand disparities, it becomes apparent from Figure 17 that Europe and Asia-Pacific represent two major regions where demand exceeds significantly the regional production. Out of these two, Europe (or more specifically industrialised Europe) is the most important demand centre imported through pipeline. (Bhattacharyya, 2011) Pipelines are the backbone of the Russian-European gas trade, while LNG is used primarily to export gas out of the Middle East and into Asia-Pacific or to export gas within Asia-Pacific (See Fig. 17).

A recent research article (Michael J. Economides a, 2009) highlights that Europe is a rapidly growing gas import market, particularly the European Union (EU), in terms of decline of indigenous production and diversification of imports. The EU is becoming more dependent on imported natural gas. Gas imports grew in absolute terms by some 28% to EU-27 from 2003 to 2007. Gas imports contribution to overall consumption in the European Union increased from some 48% to some 60% between 2000 and 2007 with LNG's share growing from 14.5% in 2003 to 15.3% in 2007 of those imports from a more diversified set of suppliers. The big three suppliers to EU-27 (Russia, Norway and Algeria) supplied some 95% of gas imports in 2003 including 85% of EU-27 supply via pipeline.

Figure 14: Non-OECD oil consumption and economic growth (GDP).

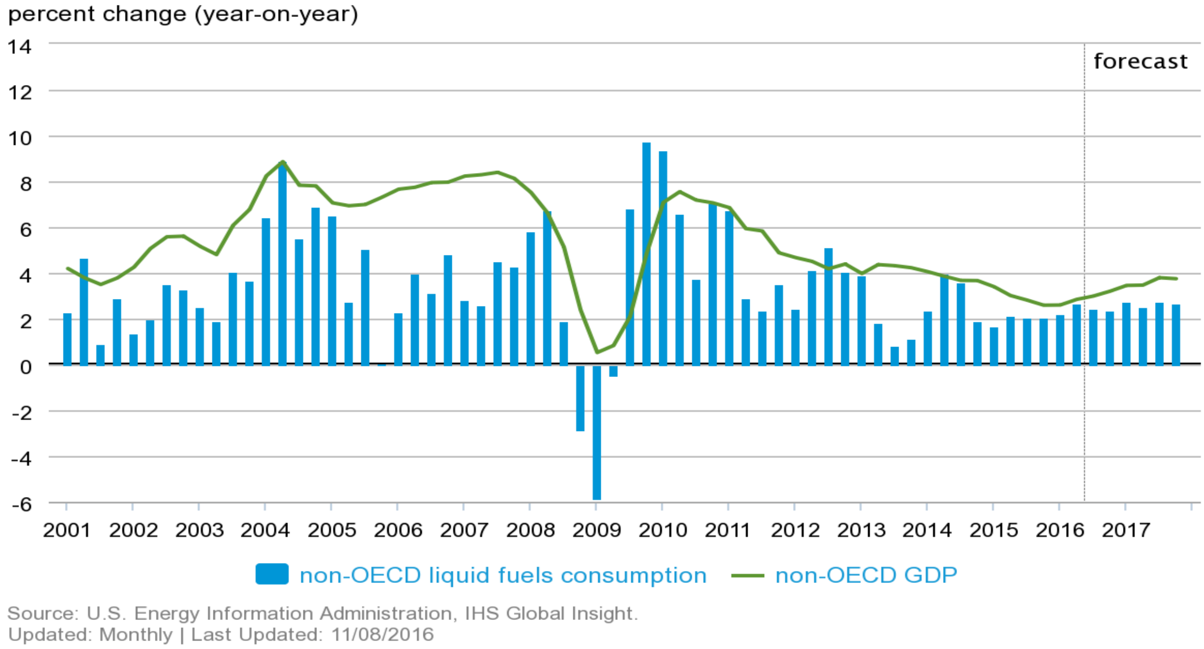
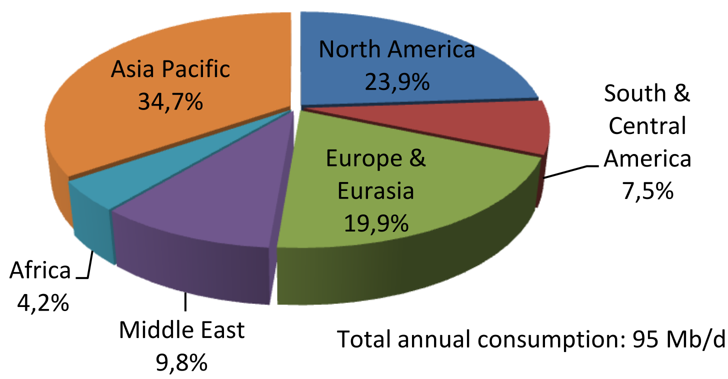
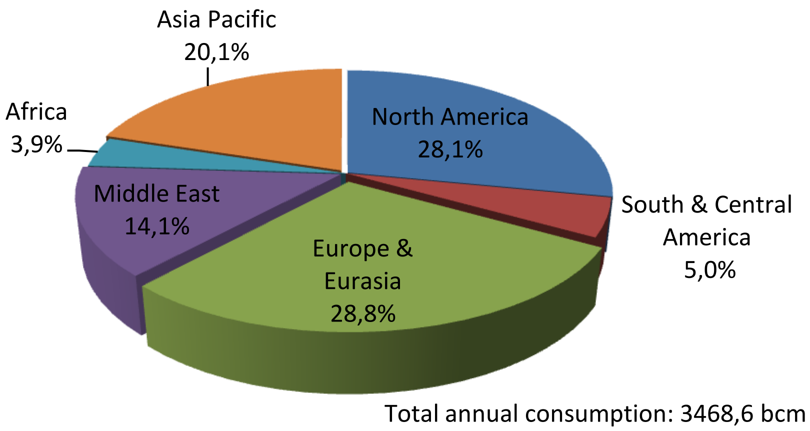


Figure 15: World Oil consumption by region 2015.



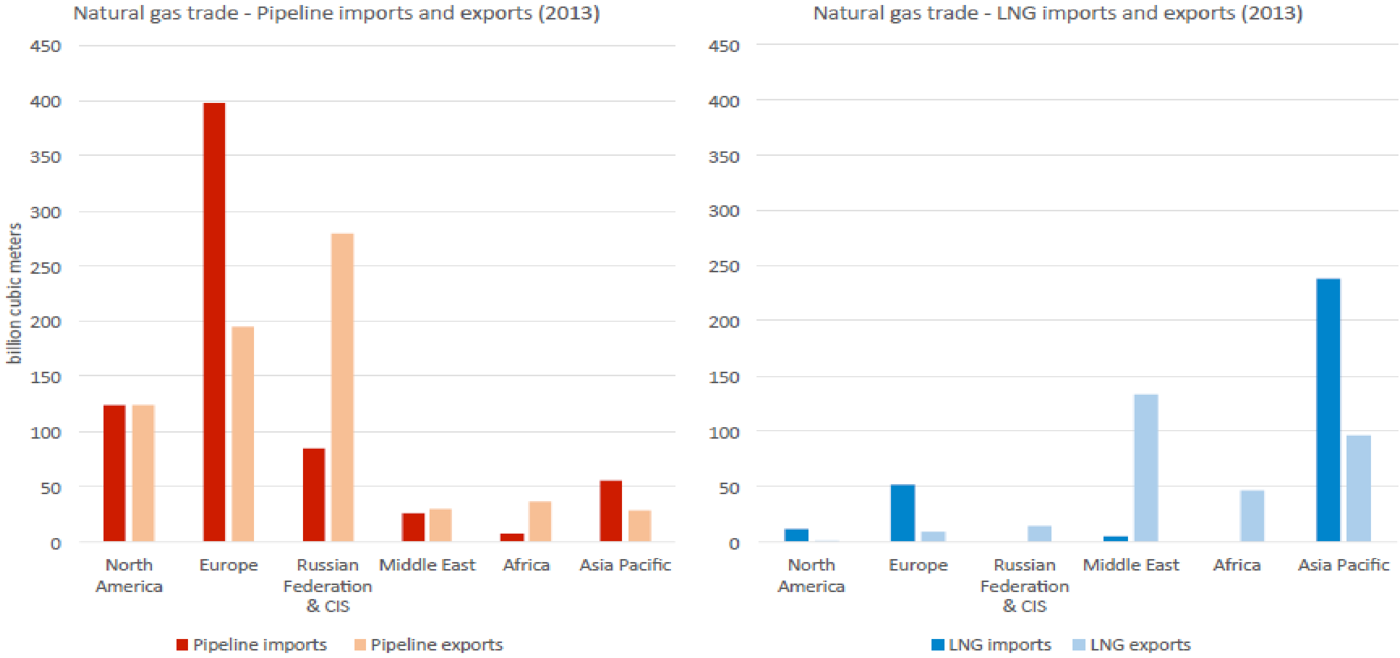
Source: BP (2016).

Figure 16: World Gas consumption by region 2015.



Source: BP (2016).

Figure 17: Natural gas trade.



Source: BP Statistical Review of World Energy (2014)

1.3 Trends and Projections

Some remarks from the previous sections are following. Oil consumption and oil production are unevenly distributed across the world. The majority of the world's oil consumption is located in North America, Europe & Eurasia and Asia & Pacific, whereas the majority of the reserves are located in the Middle East and South & Central America. Therefore, trade is well developed to satisfy the global needs. Because of the nature of natural gas, its low density and the required transportation infrastructure, which historically was mainly pipelines and often subject of geopolitical tensions, the regional distribution of natural gas consumption and production is more balanced between continents than the regional distribution for oil. Natural gas prices and markets are segmented. In Asia Pacific region is mainly traded by LNG, while Russian-Europe and North America trade is dominated by pipeline.

Among the fossil fuels there is a global trend in favor of natural gas. On the one hand, natural gas is the fossil fuel with lowest carbon intensity, therefore it is considered to contribute least to the greenhouse effect. On the other hand, due to the "shale gas boom" in the USA and an expanding infrastructure for liquefied natural gas (LNG), there is a stable outlook for gas supply. Nevertheless, the global potential of shale gas is still disputed, since outside the USA there is uncertainty around resources and there are also environmental concerns in many countries regarding the hydraulic fracturing process, for example with respect to potential contamination of groundwater.

Different scenarios exist for the projection of the future and the outcome of global energy demand and supply. BP's energy outlook (British Petroleum, 2016) highlights that by 2035, world energy demand will grow by 41% with a slower growth rate. This growth will come almost entirely from the emerging economies; their share will be 95%. Power generation will account for more than half of growth. Transport will be the slowest-growing sector, which will use natural gas, biofuels and electricity, but still will be dominated by oil. India will have faster growth in energy consumption than China, but the latter will still import and consume the most. The US will achieve energy self-sufficiency. Energy efficiency levels will improve worldwide, therefore rising economic growth will mean flattening energy demand.

Further to BP's estimations, fossil fuels will remain dominant in the global energy use by 2035, contributing a share of 81%, whereas it will be less according to EIA's (U.S. Energy Information Administration, 2016) estimation of 78% in 2040, compared to their 86% share in 2012. Oil will continue to lose ground and growth in demand for oil (0.9% p.a.) will be mainly met by the tight oil US production and OPEC. Today's imbalance of demand and supply will correct over time. Natural gas will be the fastest-growing fossil fuel (1.8% p.a.) and much of the production growth will come from shale gas.

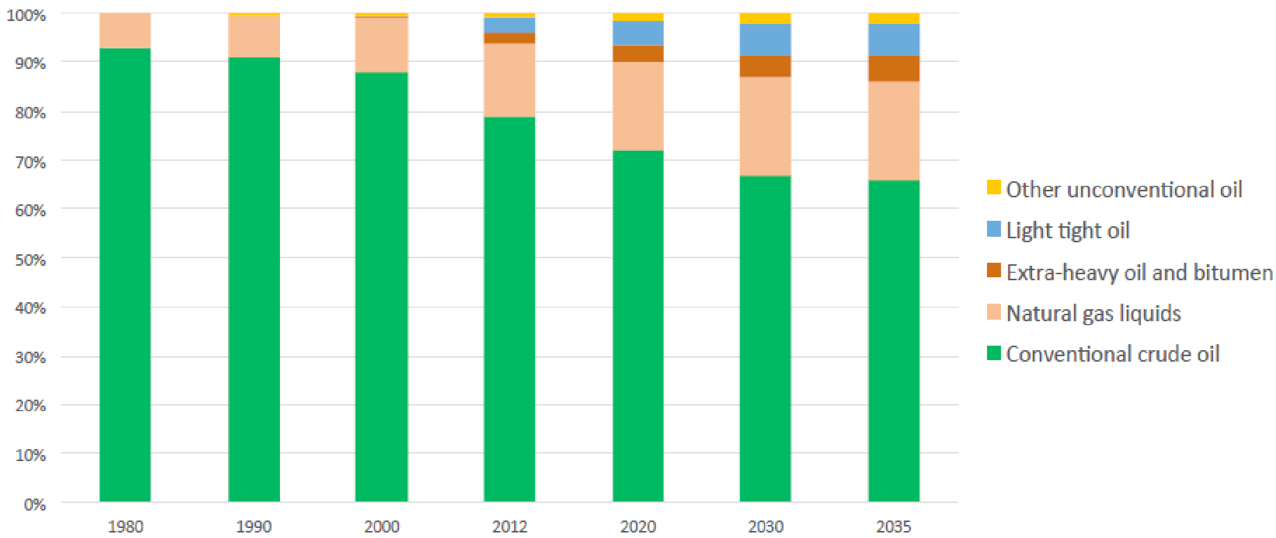
Shell has developed two possible scenarios, called Oceans and Mountains. They make clear what options exist in the world's quest for sustainable energy for the future. The Oceans scenario describes a future where, driven by market forces, the global energy landscape sees a surge in demand that brings strong social and political tensions. Emerging markets bloom, Africa becomes the 2nd largest energy-consuming country, but profit-driven motives lead to the neglect of externalities such as CO2 emissions. Fossil fuels remain important in the energy mix. The mountains scenario describes a future where, anticipating the gradual switch away from oil and coal, global policymakers take into account environmental concerns, leading to natural gas as the number one energy source. By 2030, carbon capture and storage receives major investment. Such developments enable the decarbonisation of electricity by 2060.

1.3.1 Oil and Gas Supply

Currently, there is oversupply in the oil market. Oil price decline of over 50% since June 2014, has led to a slowdown in **global oil capacity** growth as a result of both OPEC and non-OPEC producers' reduced investment. IEA highlights that investment of new conventional crude oil projects in 2015-2016 has fallen to the lowest level since the 1950s. If another year of low upstream oil investment continues in 2017, it would risk a shortfall in oil production in a few years' time, resulting in a demand and supply mismatch in the early 2020s. IEA concerns that US tight oil supply would not be enough to cover this shortfall, because US shale oil supply cannot provide an immediate response in production. However, IEA's Medium-Term Market Report of 2015, projects that the world's total oil capacity by the end of the decade is expected to rise to 103.2 Mb/d, compared to the current levels of 91.7 Mb/d at the end of 2015. Two thirds of this growth will come from non-OPEC producers. BP's (British Petroleum, 2016) base case scenario sees expansion in global liquid supply by 19 Mb/d in 2035, led by non-OPEC supply with US shale oil, tight oil elsewhere, Brazilian deepwater, Canadian oil sands and biofuels accounting for almost half of non-OPEC production.

IEA World Energy Outlook of 2013 in the New Policies Scenario (see Fig.18) foresees that from now to 2035 conventional crude oil, although falling slightly to 65 Mb/d in 2035, compared to 69 Mb/d today, will be the dominant component of total world oil supply. Within this total, the amount coming from offshore fields is relatively constant, but the share of deepwater output rises from 7% in 2012 to 14% in 2035, reaching 9 Mb/d in 2035. The offshore Arctic is another frontier area with potentially large conventional oil resources. However, extraction costs are high and environmental risks substantial. Thus, all of the growth in oil production comes from other sources. Chief among these is natural gas liquids, production of which grows by almost 40%, because the production of natural gas is expected to increase. Another source of production growth is unconventional oil, production of which rises from 5 Mb/d in 2012 to 15 Mb/d in 2035. These unconventional supplies come primarily from light tight oil[27] (LTO), Canadian oil sands and extra-heavy oil in Venezuela. The US phenomenon of the rapid increase in the production of light tight oil is represented in figure 19, along with the exponential growth of shale gas, which has been somewhat slower than shale oil. In fact, the expectation at the WEO 2013 is that after this exponential first phase (see Fig.19), the production from light tight oil in the U.S, will continue to grow with a slower pace, then reaching a peak in 2025, and declining thereafter. Natural gas liquids production in the US is predicted to follow similar pattern in the future.

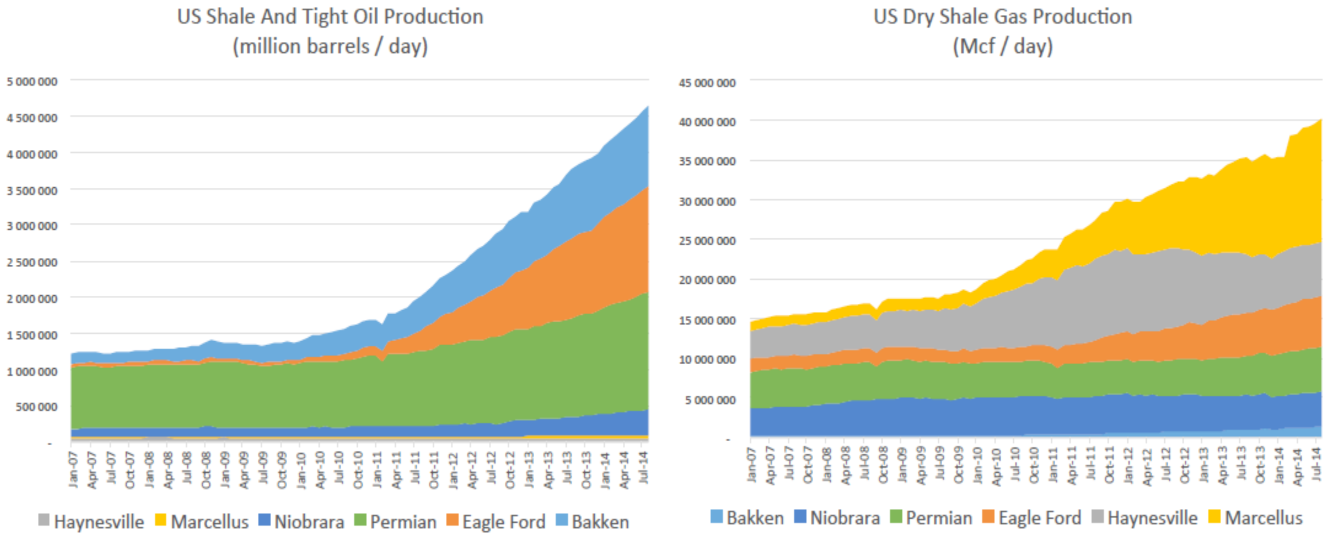
Figure 18: Shares of world oil production by type in the New Policies Scenario



Source: IEA World Energy Outlook 2013

[27] See *oil supply* subsection for more on unconventional oils category.

Figure 19: **The US shale oil and gas boom.**



Source: EIA Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays, 2011.

IEA's Market Report (International Energy Agency, 2015) identifies *two top sources of oil capacity growth* until the end of the decade. The United States remains the top source of growth through 2020, increasing by 2.2 Mb/d, with most of the expansion from LTO, which is the most elastic source of supply in a low price environment. Iraq, OPEC's second biggest producer is projected to increase capacity by 1.1 Mb/d by 2020, which accounts for nearly 90% of OPEC's total build up in capacity over the next six years. However, gains will be at risk given the political instability in the country. Canada's oil sand fields are affected by low oil prices and production will be expanded by 810 kb/d. In contrast to US LTO, Canada's output fields are projects with long payback periods. Russian output capacity contracts by about 560 kb/d up to 2020 due to the crushing impact of lower oil prices, currency depreciation and Western sanctions that compound their effect[28]. Projections further to 2040 of IEA's outlook (International Energy Agency, 2016) remarks that the world will rely on the expansion of Iran's and Iraq's production to balance the market (6 Mb/d and 7 Mb/d respectively).

Overall, OPEC crude capacity is expected to rise to 36.2 Mb/d in 2020, with annual average growth limited to 200 kb/d. As highlighted above, Iraq drives OPEC's oil supply growth, while oil's collapsed prices have dimmed the outlook in Venezuela, Nigeria and Angola. Non-OPEC oil supply is expected to grow to 60 Mb/d in 2020, at an annual average of 570 kb/d, falling below the record gains of 1.9 Mb/d in 2014, and down from an average 1 Mb/d in 2008-13. This declining growth comes from reduced capital expenses of new and existing oil fields, but is still above OPEC growth. OPEC crude supply growth rate is forecasted to rise in contrast to the declining non-OPEC, as OPEC's conventional oil fields are relatively cheaper. In IEA's World Energy Outlook of 2016, OPEC is presumed to return to a policy of active market management, but nonetheless sees its share of global production rising towards 50% by 2040, compared to its current share of 41.4% at the end of 2015.

In fact, the historical agreement of OPEC Member countries to reduce their production at the recent OPEC meeting in Vienna on 30 November 2016 and the joining of non-OPEC producers on 10th of December will bring substantial implications in balancing the global oil markets in the

[28] Russia has entered a deep economic recession in the current price environment. The second-largest non-OPEC producer relies on its oil and gas sectors for over 50% of its budget revenues. The low oil prices and sanctions-related restrictions on technology and financing all present severe challenges to its oil sector, exacerbating the overall effect of natural declines at the country's fields. (International Energy Agency, 2015)

near future. Nevertheless, even with 100% compliance from both OPEC and the other producers, global reserves are unlikely to be reduced before the first quarter of 2017, an analyst of PVM Oil Associates points out in London. Thus, rising impact on oil prices will be maybe seen later within 2017, as soon as global oil reserves are reduced.

The recent IEA Gas Market Report (International Energy Agency, 2016) predicts the outlook of natural gas in the medium-term (until 2021). Low prices and sharp cutback in investments result in slower growth in **global gas production** over the next five years. EIA (U.S. Energy Information Administration, 2016) assumes that the world's gas producers increase supplies by nearly 69% from 2012 to 2040. The largest increases in natural gas production during the period occur in non-OECD Asia, Middle East, OECD Americas, China, US and Russia. In the United States, production is expected to increase by more than 100 bcm between 2015 and 2021, accounting for one-third of global incremental production. Production growth from Russia and the Caspian region, the world's largest exporting region, slows to half the level recorded between 2009 and 2015. Weak demand in Europe and slower consumption growth in China, the two key export outlets for Russian and Caspian volumes, weigh on the region's production outlook. BP (British Petroleum, 2016) foresees that the increase in global gas supply will be roughly split between conventional and shale gas production by 2035. Traditionally growth in shale output stems from the US; however by 2035 China will be the largest contributor to growth in shale gas production according to BP (British Petroleum, 2016).

In the international gas trade, the share of LNG grows substantially by 2040; surpassing pipeline imports as the dominant form of traded gas (see Figure 22). IEA (International Energy Agency, 2016) and BP (British Petroleum, 2016) assumptions agree that global LNG export capacity is forecasted to increase by 45% between 2015 and 2021, 90% of which originates from the United States and Australia. Almost all of the projected increase comes from projects which have already been under development. There is a new diversity among suppliers, with Australia, North America and East Africa all emerging as major exporting regions, in particular, Australia, US, Mozambique, Tanzania and Canada. In Europe, as many contracts with Russia are coming to an end in early 2020s, there will be exactly the time when a lot of LNG quantities will come into the market. Oversupply in global LNG markets will lead to fierce competition, with flexible US and Qatari volumes set to fight hard to gain access to European customers. As a result, Gazprom in order to achieve its stated strategy of maintaining market share in Europe, it will need to adopt a more competitive pricing mechanism than in the past.

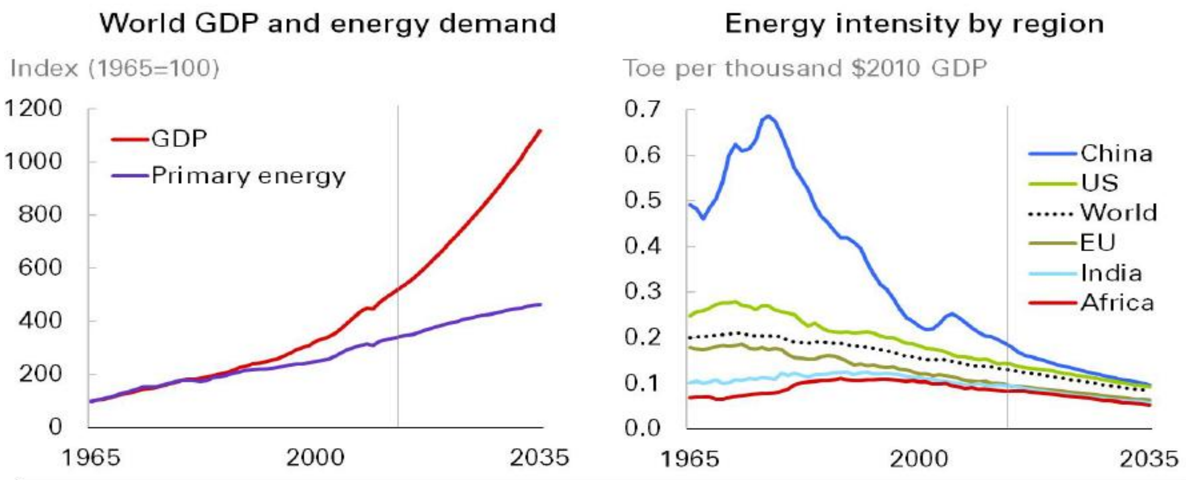
According to a research paper by the Congressional Research Service, the USA will become a net exporter of natural gas by 2016 due to the development of shale gas. EIA (U.S. Energy Information Administration, 2016) expects that US will become a net exporter in 2018, with LNG exports accounting for most of the growth. IEA predicts that the USA will become the third largest exporter of LNG by 2020. Australia is expected to overtake Qatar as the world's biggest supplier of LNG by 2020. BP (British Petroleum, 2016) on the contrary expects US to become a net exporter of gas and major exporter of LPG by 2035, to both Europe and Asia Pacific markets.

1.3.2 Oil and Gas Demand

The main scenario of IEA's World Energy Outlook of 2016, forecasts that global energy demand will rise 30% in 2040 as global GDP grows, compared to the increase of 60% during the last 25 years. EIA (U.S. Energy Information Administration, 2016) sees even larger increase of 48% in 2040. This assumption of IEA for the next 25 years agrees with BP (Figure 20), about the global energy demand is due to increased efficiency improvements, which also affects oil and gas demand. Total demand in OECD countries follows a relative declining path between 2012 and

2040 (an 18% increase (U.S. Energy Information Administration, 2016)), while the geography of global energy consumption continues to shift towards non-OECD nations as a result of strong economic growth (an 71% increase (U.S. Energy Information Administration, 2016)); industrializing, urbanizing India, Southeast Asia and China, as well as parts of Africa, Latin America and the Middle East. China and India, in particular, have been among the world's fastest-growing economies over much of the past decade. Natural gas performs best among the fossil fuels, with consumption rising by 50%. Growth in oil demand slows over the projection period, but tops 103 Mb/d by 2040. However, by the mid-2030s developing countries in Asia consume more oil than the entire OECD. Hence, oil trade shifts towards Asia, while United States eliminates net imports of oil by 2040.

Figure 20: World GDP and energy demand, Energy intensity by region



Source: BP World Energy Outlook 2016

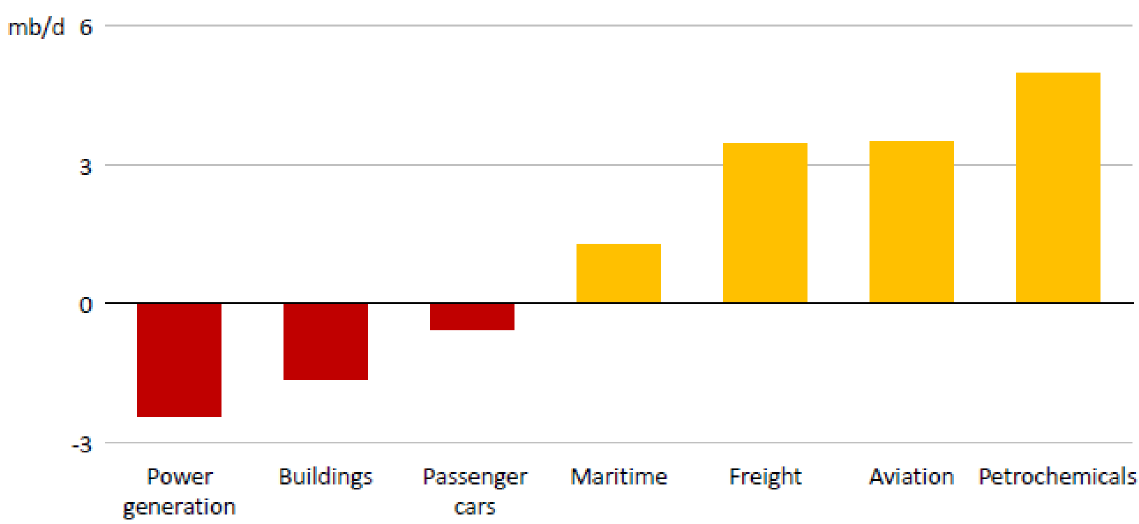
According to IEA's Market Report (International Energy Agency, 2015), projections of **oil-demand** growth have been revised downwards, since the price drop, in line with IMF forecasts of future economic growth. The fact that global economy has become less oil-intensive than in the past, coupled with the diminishing role of oil in the fuel mix, will further mute the demand impact of lower prices. Mature OECD markets will see contraction in oil demand in the years to 2020, while non-OECD oil demand is only expected to grow by 1.19 Mb/d annually, but this is far less than its historical rate of growth. However, demand growth is still projected to gain momentum from recent lows as the global economy slowly improves, but in a slower pace. Demand is now forecast to run ahead of supply gains by as much as 1 Mb/d over the next six years, resulting in significantly tighter balances by the beginning of the next decade.

Meanwhile, on the one hand, as oil exporting economies face adverse effects of oil price drops, by seeing their revenues reduced, on the other hand, oil importing countries are not in the expected beneficial position. Their benefit of both rising disposable income and lower production costs will be partly offset by underlying problems of the broader economy. In several large OECD economies, falling prices may feed into deflation expectations. In many cases, weak currencies fluctuations will blunt the benefit of the decline in oil prices, as governments cut their subsidy programs or raise consumption taxes. As a result end-users might not see as much relief from the drops as it would appear. (International Energy Agency, 2015)

IEA (International Energy Agency, 2016) is concerned about energy security still being a major issue, but can be dealt with a variety of tools, which result in reduced net oil imports in key countries, such as US, EU, China and India. Not only by increases in domestic oil production, but also by efficiency improvements in transportation which are bringing down the consumption, result in reduction of oil imports. The much referred energy transition (initiated by climate change agreement) helped to the development of additional factors to address traditional energy security concerns; these are switching to renewable energies and electric and natural gas vehicles.

Over the longer term, IEA's (International Energy Agency, 2016) main scenario projects that three sectors account for all the growth in global oil consumption: freight, aviation and petrochemicals, areas where alternatives are scarce (see Figure 21). Although, it is expected a doubling in car fleet by 2040, from 1 billion to 2 billion cars, the use of oil will slightly decline. The main reason why the amount of oil declines even though fleet doubles, is because of efficiency with additional contribution of use of natural gas and electric cars. Impressively enough, according to IEA's estimates, one-third of the global oil demand growth comes from the development in trucks of Asian countries only. In line with BP's of (British Petroleum, 2016) projection which claims that growth in liquids demand will come mainly from transport and industry by 2035, with transport accounting for almost two-thirds of the increase. Moreover, IEA foresees that total demand from OECD countries falls by almost 12 Mb/d to 2040, but this reduction is more than offset by increases elsewhere. India and China are the largest sources of future demand growth, sees oil consumption rise by 6 Mb/d and 5 Mb/d respectively. Elsewhere the Middle East sees oil demand climb by 3.5 Mb/d, other non-OECD Asian countries by 2.7 Mb/d, and Africa by 2.5 Mb/d. Alternatively, IEA's (International Enegy Agency, 2015) Low Oil Price Scenario, demand is pushed up to over 107 Mb/d by 2040, nearly 4 Mb/d higher than in the New Policies Scenario, with most of the incremental demand coming from transport. Middle East's share in the oil market ends up higher than at any time in the last forty years. Lower prices stimulate oil use and diminish the case for efficiency investments, meaning longer payback periods, holding back the much-needed energy transition.

Figure 21: Change in oil demand by sector, 2015-2040.



Source: IEA World Energy Outlook 2016

China's transition to an economic model oriented towards domestic consumption and services play a critical role in shaping global trends. The build-up of China's infrastructure in recent decades relied heavily on energy-intensive industrial sectors, notably steel and cement. However, energy demand from these sectors is now past its high point and economy is rebalancing towards a serviced-based economy, meaning that less energy is required to generate economic growth. Also, the country's energy mix is becoming more diverse, with coal and oil losing significant market share, while gas, nuclear and renewable energy growing.

Finally, according to World Bank data[29], oil prices seem to follow a slow upward trend during 2016, as the price of Brent on January 2016 was 30 USD/bbl and further on December 2016 the price reached 54 USD/bbl, an overall increase of 80%. In contrast to the previous year, since June 2014 the oil prices were falling. Despite the Brent crude price seemed promising the first 5 months of 2015, it reached a high 64 USD/bbl; on the whole it followed an downward trend from June of 2015 and thereafter it fell to almost 38 USD/bbl, a decline of 60%.

IEA's latest Report (International Energy Agency, 2016) forecasts **natural gas demand** to reach 3.9 tcm in 2021, increasing at an average annual rate of 1.5%, compared to the current consumption of 3.5 tcm at the end of 2015. It points out a slower global gas demand growth, along with the trend of reducing energy intensity in the world economy which is lessening demand growth for all fossil fuels, including gas. Despite the slower global gas demand growth, the share of gas in the world's energy mix will still increase marginally over the next five years. From 2012 to 2014, EIA (U.S. Energy Information Administration, 2016) predicts that global natural gas consumption will increase by 1.9% per year on average mainly by power and industrial sector, together will be accounting for 75% of the total increase.

In Asia, where the fall in gas prices has been the most dramatic, gas demand growth has weakened considerably. The absence of a direct link between demand and prices suggests that other factors, particularly in the power sector, have offset the impact of cheap gas. It is difficult for gas to compete in a world of very cheap coal, falling costs and continued policy support of renewable energy. In China, while industrial activity is slowing, there is a stagnant growth of electricity generation, but government is trying to increase gas's share in the country's energy mix. As the country is undergoing into economic and energy transformation, IEA finds high risk to any further forecast. (International Energy Agency, 2016)

In India, a highly price-sensitive market, gas demand is set to grow robustly, at an annual average rate of almost 6% over the forecast period of the report (International Energy Agency, 2016). The country's gas sector is going to expand in the future, aiding by the recent sharp falls in international benchmarks in conjunction with significant revisions to domestic pricing policies and continued gradual progress in building out gas infrastructure.

In the Middle East, cheaper oil prices and slower economic activity lower the underlying trajectory for gas demand in both the electricity and industrial sector. However, the key challenge for the region remains on the supply side with several countries struggling to lift production adequately to meet global demand growth. (International Energy Agency, 2016)

In the United States, the top world consumer as of 2015, demand growth will slow as US thermal generation is expected to decline until the 2021 due to federal incentives that promote the use of low-carbon sources, such as solar and wind. (International Energy Agency, 2016) However, EIA (U.S. Energy Information Administration, 2016) predicts that natural gas US consumption grows by 0.9% per year until 2040, leading by electricity generation and industrial sector.

European gas demand is projected by (International Energy Agency, 2016) to increase very modestly, with small increases in the power sector offsetting small declines for residential and

[29] http://databank.worldbank.org/data/reports.aspx?source=global-economic-monitor-(gem)-commodities, accessed on 21 January 2017

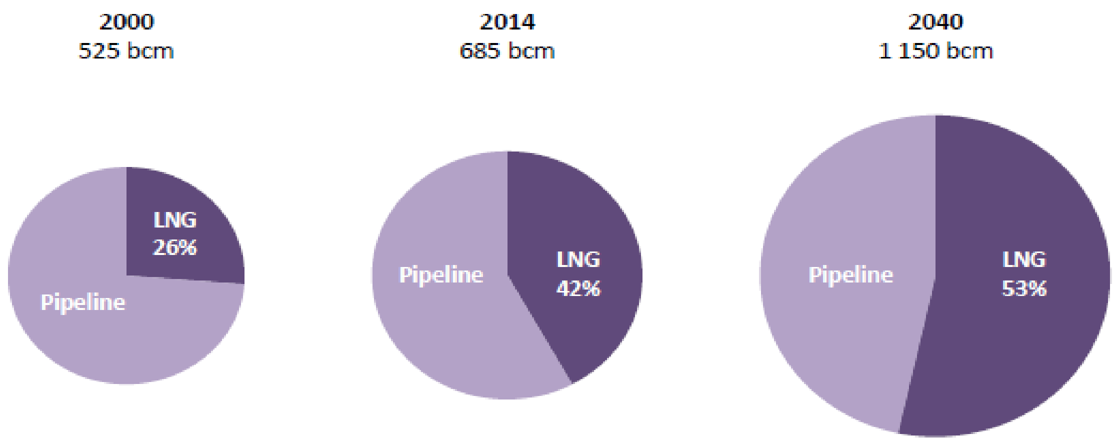
commercial. In addition, Europe's flexibility to import additional LNG is limited by the slow demand growth, cheap coal, and competitive Russian supplies.

LNG demand in Japan and Korea, which today account for almost 50% of global LNG imports, is forecast to stagnate or even decline sharply depending on the scale of nuclear comeback in Japan. Latin America and the Middle East offer pockets of growth, but neither of these regions is a natural home market for base-load LNG imports. By 2021, LNG imports among developing Asian economies (including China) are forecast to increase by more than 100 bcm. (International Energy Agency, 2016)

As far as gas LNG prices are concerned, they tend to converge across regional benchmarks, helped by much lower oil prices. In the first five months of 2016, the average differential between Asian LNG spot prices and US prices was just USD 2.5/MBtu; a far cry from the average spread of around USD 11/MBtu that had prevailed between 2011 and 2014. Over the next few years, well-supplied gas markets and flexible LNG supplies from the US are set to keep global spot prices under pressure, helping also in the convergence of the regional spot prices. However, oil-indexation in Asian gas prices will remain, but lessen by a period of oversupply. (International Energy Agency, 2016)

Over the longer term, IEA's outlook (International Energy Agency, 2016) forecasts that gas consumption increases almost everywhere by 2040, with the main exception of Japan where it falls back as nuclear power is reintroduced. The gas market is transformed into both a truly global market and a more flexible one, as LNG trade doubles, supporting an expanded role for gas in the global mix. China and the Middle East are the largest sources of growth. The development of a more globalised market and its status as the least-polluting of the fossil fuels helps gas gain ground, overtaking coal in the global mix. More competitive and flexible arrangements are expanding, more and more contracts will be short-term with greater reliance on prices set by gas-to-gas competition.

Figure 22: Share of LNG in global long-distance gas trade.



Source: IEA WEO 2016 Presentation

There are many risks and uncertainties that may affect the projected trends and in the end the outcome of the future. Some of them are explored in BP (British Petroleum, 2016); technological advances, oil price volatility, slower global GDP growth, faster transition to a lower-carbon world and shale oil and gas greater potential which may alter the energy landscape over the next 30 years. However, projections also may differ as a result of different assumptions. Some projections may include assumptions about policy developments about carbon emission or other environmental issues over the period. For example, IEA (International Energy Agency, 2016) main scenario includes targets for energy efficiency improvements, and implementation of climate pledges, whereas (U.S. Energy Information Administration, 2016) reference case reflects the effects of current policies within the projections.

2. Maritime Transport: The international transport system of liquid energy goods[30]

The importance of sea transport in the early stages of economic development is well known to economists. The crucial role of shipping was recognized by early economists; among them the "father" of economics, Adam Smith, argued that in primitive economies shipping is more efficient that land transport, allowing trade to get started earlier. In addition, economic development is a driver of growth in the global trade, which also boosts seaborne trade and international shipping. Therefore, not only sea trade is a trigger for economic growth at an early stage, but it is also enhanced during the process as the economy enlarges.

Maritime shipping is a global industry. In 2015 estimated by UNCTAD world seaborne trade volumes surpassed 10 billion tons, accounting for over 80% of total world merchandise trade. In value terms of 2004, the maritime industry's annual turnover was over USD 1 trillion. Although merchant shipping accounts for roughly a third of the total maritime activity[31], its turnover in 2004 was by far the biggest of all, contributing about USD 426 billion. The business has seen very rapid growth the last decade due to the freight market boom which was just starting in 2004. In 2016 value terms, the share of maritime trade has estimated at over two thirds of total merchandise trade (IHS Markit, 2016). Although the aforementioned figures contain estimates, they provide a helpful insight into what is the role of the business. In 2007, merchant shipping operated a fleet of 74,398 ships, of which 47,433 were cargo vessels. In the start of 2016, the world commercial fleet consisted of 90,917 vessels with a combined 1.8 billion dwt, a 22% growth in 9 years. Ships, the industry's main assets, are physically mobile, and international flags allow shipping companies to choose their legal jurisdiction, and with it their tax and financial environment. It is also ruthlessly competitive, and some parts of the industry still conform to the "perfect competition" model developed by classical economists in the nineteenth century.

The modern international transport system consists of roads, railways, inland waterways, shipping lines and air freight services, each using different vehicles. In practice the system falls into three zones: inter-regional transport, which covers deep-sea shipping and air freight; short-sea shipping, which transports cargoes short distances and often distributes cargoes brought in by deep-sea services; and inland transport, which includes road, rail, river and canal transport. For high-volume inter-regional cargoes deep-sea shipping is the only economic transport between the continental landmasses, as it is the only means of transport which takes advantage of economies of scale. Therefore, the volume of cargo transported through the deep sea-shipping is traditionally much larger than air freight. Although, the different sectors of the international transport system compete with each other, technical development also requires close cooperation of each component for the development of ports and terminals designed for efficient cargo storage and transfer from one mode to another.

[30] The introductory part of this section is a collection of notes from various chapters of the book (Stopford, 2009), which it was considered appropriate to mention.

[31] The book (Stopford, 2009) divides the maritime activity into five groups: vessel operations; shipbuilding and marine engineering; marine resources, which include offshore oil, gas, renewable energy and minerals; marine fisheries; and other marine activities, mainly tourism and services. Merchant shipping is included in vessel operations together with naval shipping, cruise industry and ports.

Shipping companies operate their vessels offering sea transport services. They adjust their supply by building new ships in the new building market, or acquiring second-hand vessels in the sale and purchase market, leading by the demand for shipping services. With regard to tanker shipping market, the demand for tanker transportation derive from seaborne trade in energy products, as the demand for tankers is driven by the demand for tanker shipping services and the latter is depending on the volumes of trade. On the other hand, the supply of shipping service is fleet size in the tanker shipping market. As regards the demand for trade, trade flows of cargo are usually driven by economic forces, but some specialist cargoes are often traded for competitive reasons or other strategic reasons between continents. There are three different categories, by the economic point of view, which drive trade. First, there is supply and demand deficit trade, which occurs when a product moves from areas of surplus to areas of shortage. This is very common in the primary material trades, which are carried in bulk. Second, there is competitive trade. A country may be capable of producing a product, but cheaper supplies are available overseas. Or consumers or manufacturers may wish for diversity. Third, there is cyclical trade which occurs in times of temporary shortages, or business cycles.

Seaborne trade of energy goods is dominating bulk shipping. As of 2006, this group of commodities, which share accounts for 44% of the total tonnage of seaborne trade, comprises crude oil, oil products, liquefied gas and thermal coal. (Stopford, 2009) Excluding coal, the trade of liquid energy commodities has experienced the largest growth out of the group of bulk commodities in 2015, according to UNCTAD (United Nations Conference on Trade and Developement, 2016). Crude oil shipments are estimated to have increased by 3.8% in 2015, following two consecutive annual contractions in 2013 and 2014. Petroleum products and gas trade together expanded by 5.2% in 2015, rise up from 2.6% in 2014. Major, minor dry bulk commodities and other dry cargo increased by 1.2%, 1.5% and 2.6% respectively.

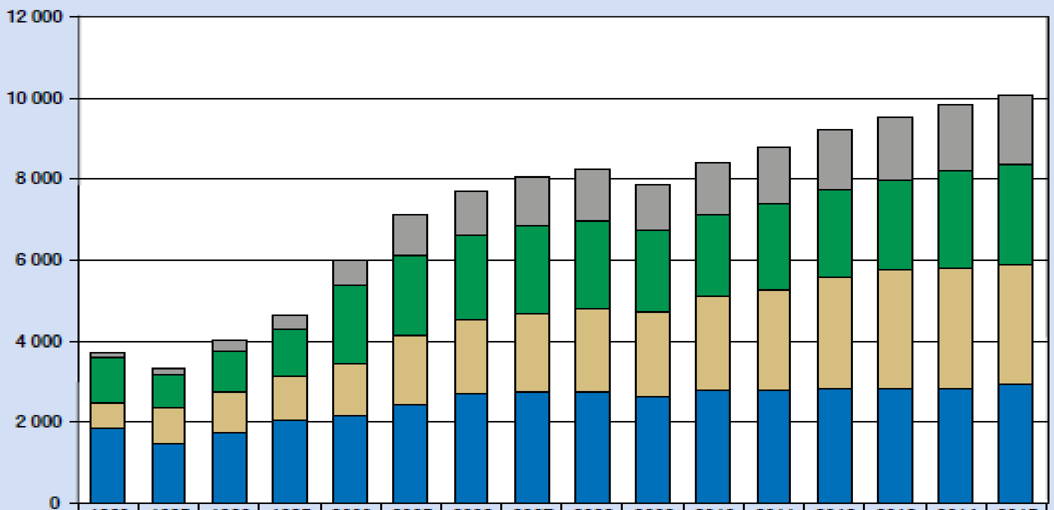
Liquid energy commodities are carried in bulk by tankers that are divided into different categories, based on the type of transported cargo. There is a diverse fleet of tankers which transport crude oil, oil products, chemicals, liquid gases and specialist cargoes. These ships serve the energy, chemical and agricultural businesses which are their main customers. The oil tankers transport crude oil and oil products. The specialized tankers transport liquefied natural gas (LNG) and liquefied petroleum gas (LPG). Moreover, there are also tankers carrying chemicals such as ammonia, phosphoric acid, caustic soda. According to UNCTAD (United Nations Conference on Trade and Developement, 2016), in 2015 there were transported approximately 8 billion tons of bulk commodities, around 80% of the total sea trade. This total included 2.9 billion tons of liquid commodities that are oil and gas, and represents more than a quarter of the total seaborne trade.

Figure 23: World tanker fleet as of January 2012 and 2016.

	2012			2016			Av.
Ship type	No	mill dwt	mill cbm	No	mill dwt	mill cbm	dwt/cbm growth
Total Oil tankers	**11324**	**492.3**	**-**	**12269**	**545.7**	**-**	**2.6**
- Crude/product tankers	*6576*	*408.4*	*-*	*7065*	*443.9*	*-*	*2.1*
- Oil/chemical tankers	*4748*	*83.9*	*-*	*5204*	*101.7*	*-*	*5.0*
Liquid gas tankers	**1567**	**44.0**	**72.7**	**1770**	**54.5**	**90.4**	**5.6**
- LPG tankers	*1194*	*15.1*	*19.6*	*1327*	*19.4*	*25.8*	*7.2*
- LNG tankers	*373*	*29.0*	*53.1*	*443*	*35.0*	*64.6*	*5.0*
Total	**12891**	**536.3**	**72.7**	**14039**	**600.1**	**90.4**	*2.9*

Source: ISL Shipping market review 2016.

Figure 24: **International seaborne trade (Millions of tons loaded)**



	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Containers	102	152	234	371	598	1 001	1 076	1 193	1 249	1 127	1 280	1 393	1 464	1 544	1640	1687
Dry cargo other than main bulk commodities	1 123	819	1 031	1 125	1 928	1 975	2 112	2 141	2 173	2 004	2 022	2 112	2 150	2 218	2393	2463
Main bulk commodities	608	900	988	1 105	1 295	1 711	1 814	1 953	2 065	2 085	2 335	2 486	2 742	2 923	2985	2951
Oil and gas	1 871	1 459	1 755	2 050	2 163	2 422	2 698	2 747	2 742	2 642	2 772	2 794	2 841	2 829	2 825	2 947

Source: UNCTAD, Review of Maritime Transport 2016

2.1 Global tanker fleet

The tanker fleet is split into five segments known in the industry as VLCCs, Suezmax, Aframax, Panamax, Handy (sometimes called 'Products') and small tankers. Their tonnage size ranges from 550.000 dwt to 10.000 dwt. These different sizes operate in different trades, with the bigger vessels working in the long-haul trades, but there is much overlap, i.e. some Aframaxes carry oil products and some product tankers carry chemicals. VLCCs carry the long-haul cargoes, particularly those that transport oil to Asian countries; Suezmaxes operate in the middle-distance trades such as from West Africa to the USA or Middle East to Europe through the Suez Canal; Aframaxes trade in shorter-haul trades such as across the Mediterranean; Panamaxes trade in the Caribbean; and the Handy tankers carry mainly oil products. There is also a fleet of small tankers which operate in the short sea trades. As of 2007 (Stopford, 2009) statistics, the fleet of deep-sea tankers averages about 9 years old, while handy together with small tankers average about 20 years old. Comparing the fleet age of deep-sea tankers with the rest market segments' fleet, it is noticeable that the fleet of deep-sea tankers was renewed, reflecting regulatory pressures in the last decade. Recent data (United Nations Conference on Trade and Developement, 2016) indicate that among the main vessel types, the newer fleet in early 2016 was that of dry bulk carriers; 42.8% of dry bulk ships are between 0 and 4 years old, while 22% of tankers are younger than 5 years (Clarkson Research Services Limited, 2015).

The best way to understand the trade is to start by looking at its physical characteristics. From a transport viewpoint, oil cargoes can differ in two important respects: specific gravity; and the standards of cleanliness needed to transport it. From heavier to lighter with specific gravity close to 1 at the top and 0.69 at the bottom, oil cargoes are categorized as it is illustrated in the table 5. Heavier products have higher specific gravity and they are essentially the *'dirty' tanker products*. The lighter ones have substantially lower density and they fall into the *'clean'* category. This simply means that the shippers are more sensitive with these products which should not be polluted by any traces of the previous transported cargo. Gas oil is a transitional product, in the sense that carrying several cargoes of gas oil helps to clean up the tanks after carrying a dirty cargo. Finally, the table gives the typical parcel size in which these commodities are shipped. These three characteristics – the density of the oil; the parcel size in which it is shipped; and the degree of care and cleanliness required in handling the cargo – set the framework for the oil transport system. (Stopford, 2009)

Table 5: **Oil cargoes characteristics**

	Density at 15°C						Stowage/tonne	
	Specific gravity	°API	Range + or –	Cargo type	Special characteristics	Typical cargo size- tons	Cu. ft	M³
Heavy fuel oil	0.98	13.53	3%	Dirty	Cargo heating	50-80,000	32.8	0.93
Heavy crude oil	0.95	17.34	3%	Dirty	Cargo heating	60-300,000	33.7	0.95
Diesel oil	0.86	32.92	3%	Dirty		40,000	37.2	1.05
Light crude oil	0.85	34.85	3%	Dirty		60-300,000	37.6	1.07
Gas oil (light fuel oil)	0.83	38.86	2%	Mainly clean		30,000	38.6	1.09
Paraffin	0.80	46.36	2%	Clean	Clean tanks	30,000	40.3	1.14
Motor spirit (petrol)	0.74	59.58	5%	Clean	Clean tanks	30,000	43.2	1.22
Aviation spirit	0.71	67.65	3%	Clean	Clean tanks	30,000	45.1	1.28
Naphtha	0.69	73.43	4%	Clean	Clean tanks	30,000	46.4	1.31

Source: **(Stopford, 2009)**

Different ship owning countries also specialize in different vessel types. In 2016, countries with economies in transition had the highest share of oil tankers, many of which were owned by the Russian Federation. However, the majority oil tanker fleet is registered in developing countries as of data of 2016, accounting for 81.08%, while 18.70% of the oil tankers are registered in developed countries. (United Nations Conference on Trade and Developement, 2016)

2.1.1 Recent developments on demand and supply

From the **demand side**, UNCTAD's review (United Nations Conference on Trade and Developement, 2016) points out that in 2015 the tanker trade sector experienced one of its best performances since 2008, supported in particular by an ample supply of oil cargo and lower oil prices. Crude oil imports into Europe, China and India increased significantly in 2015, which stimulated seaborne trade and therefore demand for sea transport. In particular, estimates by Clarksons Research refer that this recent increase was primarily due to robust Chinese crude oil imports which accounted for about half the growth, as volumes increased by 9.3%. Estimates of ISL (Institute of Shipping Economics and Logistics, 2016) indicate that in 2015 seaborne crude oil trade increased 4.7% up to 1.8 billion tones, while oil products climbed about 2.2% to 1.0 billion tones. Global seaborne crude oil trade expanded faster than oil demand in 2015 and reversed the downward trend of 2014 due to a number of important factors. The factor that led this expansion in oil trade was not so much an increase of end-user oil demand as additions to refinery capacity and low oil prices leading to greater demand for oil storage. Also, two major developments in regional regulations in 2015 had significant implications on crude oil trade. The United States lifted a 40-year ban on crude oil exports and some sanctions on the Islamic Republic of Iran have been lifted, allowing for the return of its crude oil to the market, which is expected to add more pressure on oil supply. However, the infrastructure of US ports does not support large tankers; consequently Aframaxes cover the trades in the region. Product tankers also recorded progress in 2015, due to increases in refinery capacity, product exports from the Middle East, and import demand in Asia, Australia, India and Europe. (United Nations Conference on Trade and Developement, 2016) From a global perspective, according to ISL (Institute of Shipping Economics and Logistics, 2016) the biggest refinery capacity is located in the USA, equivalent to 18.4% of the global capacity at the start of 2015. China has the second biggest refinery capacity with share 14.6%, followed by Russia (6.6%), India (4.5%) and Japan (3.9%). All these countries together are accounting for nearly half of the global refinery capacity.

Danish Ship Finance review (Christopher Rex, 2016) mentions that crude tankers demand was held back during the year 2016 in contrast to the previous year, as oil prices started to show signs of upward movement, limited expansion in refinery capacity, high oil inventories and sluggish economic growth. On the other hand, product tankers demand has remained artificially high during 2016, as high refinery margins were not affected by overproduction and rising oil prices, resulting in a huge build-up in oil product stocks in all key importing areas. Today, excessive volumes of oil are still being imported and global oil inventories continue to build for both crude oil and refined oil products, reflecting a short-term oversupply.

Further to UNCTAD maritime review (United Nations Conference on Trade and Developement, 2016), from the **supply side**, the world fleet grew by 3.5% from 2015 to January 2016 in terms of deadweight tons (dwt). This is the lowest growth rate since 2003, yet still higher than the 2.1% growth in demand, leading to a continued situation of global overcapacity. Data from (Stopford, 2009) of 2006 suggest that oil tankers formed the largest fleet of specialist bulk vessels, with over 6,000 vessels, accounted for 37% of the merchant fleet measured in dwt. On the contrary, UNCTAD review (United Nations Conference on Trade and Developement, 2016) highlights that nowadays the largest share owns the fleet of dry bulk carriers with 43.1% (Percentage share of deadweight tonnage of 2016), followed by the oil tankers with 27.9% of the total world fleet. Oil tanker fleet increased 3.08% in terms of dwt from 2015 to 2016. According to ISL (Figure 23) at the 1st of January 2016, the crude oil and oil product tanker fleet comprised 7,065 tankers with 444 million dwt. ***Crude tanker fleet*** capacity remained low in 2015, which increased less than 1%. Despite most shipping segments in 2015 endured volatility and downward movements breaking below operating costs, all tanker segments performed well resulted in strong tanker earnings which have benefited from strong freight rates and low bunker prices. *Average tanker earnings* per vessel rose to an average of USD 31,036 per day, an increase of 73% over 2014, the highest level since 2008. The largest gains were observed in the VLCC segment which more than doubled to almost reach USD 60,000 per day exceeding USD 100,000 in December 2015. Suezmax earnings rose by 68% to USD 46,713 per day, while average Aframax earnings increased by 54% to USD 37,954 per day. Dirty Panamax earnings also improved, reaching an average of USD 26,548 per day in 2015, the highest level since 2008. ***Product tankers,*** which carry both clean and dirty oil products, also recorded some progress. (United Nations Conference on Trade and Developement, 2016) In general, tanker market sentiment in 2015 strengthened for vessels in different segments, with spot freight rates for both dirty and clean tankers edged up by 11% despite an increase in tanker capacity seen during the year.

Danish Ship Finance review (Christopher Rex, 2016) sees that the high tanker earnings of 2015 have not continued in 2016. Oversupply issues are now also affecting the tanker segments which have seen steep freight rate declines during 2016. ***Crude Tanker fleet*** has expanded by approximately 5% compared to around 2% of 2015. Last year's rising freight rates, created by a combination of factors – such as low inflow of new vessels and surplus of crude oil - increased owners' appetite for ordering new vessels. The need for transportation and storage of crude oil has continued to grow in 2016, since global oil markets have remained excessively supplied. However, timecharter rates dropped by approximately 40% during the first eleven months of 2016 while the value of a 10-year-old vessel dropped by approximately 30%. VLCC earnings dropped 40% to USD 30,250 per day from January to November 2016, Suezmax earnings decreased by 38% to USD 22,500 per day, Aframax earnings declined equally to Suezmax rate to USD 17,250 per day. Moreover, only seven vessels have been scrapped during the first ten months of 2016, suggesting that ship owners are still somewhat optimistic about the future. Only 17% of the crude tanker fleet is older than 15 years, so that can be scrapped to balance the market and maintain freight rates. Lower tanker earnings are also reducing the vessel prices. The second-hand values of ships aged between 5 and 15 years old dropped by between 25% and 35% in 2016 and newbuilding prices declined approximately 10%. The price of a 5-year old VLCC dropped from USD 80 million in January 2016 to USD 60 million in December 2016. (Christopher Rex, 2016)

Danish Ship Finance review (Christopher Rex, 2016) highlights that freight rates of product tankers have plummeted during the first eleven months of 2016. ***Product tanker fleet*** grew by 5% during the first ten months of 2016. Trading activity is not sufficient to employ the steady inflow of vessels, and consequently timecharter rates have dropped since their peak in the summer months of 2015. The 1-year timecharter rate dropped by almost 50% during the first eleven months of the year, while the average value of a 10-year-old MR vessel fell by more than 20%. Aframaxes were being chartered for one year at USD 31,000 per day in August 2015, but the average rate was 50% lower at USD 16,000 per day in November 2016. Product earnings usually decline in the third quarter of each year when seasonal maintenance at refineries takes place. This year has been no different but the decline in earnings has been exacerbated by the oversupply of refined petroleum products. Clarksons' Average Clean Products Earnings has declined from more than USD 28,000 per day in July 2015 to USD 8,395 per day in November 2016. Despite the deteriorating freight rate environment, ship owners took delivery of 80% of the orders, only 20% of their scheduled orders were postponed for later delivery. In addition, scrapping remained low; only 24 vessels with a combined capacity of 0.7 million dwt were scrapped during the period, one of the lowest levels seen in the last decade. New building prices have decreased by around 10% in 2016 and secondhand prices fell by more than 20% in the first ten months, reflecting reduced expectations for future earnings. (Christopher Rex, 2016)

In short, 2015 was one of the best years in terms of profits and trade for oil tankers, the gap between crude tanker supply and demand narrowed, while the fundamental gap of product tanker supply and demand widened. The crude tanker fleet grew by 2%, while seaborne crude oil volumes increased by 4% during 2015. The product tanker fleet grew by 6%, while demand for seaborne petroleum products contracted by 1% in 2015. However, overall supply, i.e. crude and product tanker shipping capacity, increased faster than demand, i.e. crude and product oil trade volumes in 2015, leading to overcapacity being the situation for the rest segments of the shipping industry. Nevertheless, this exceeded supply reduced by using tankers as storage units. The situation of overcapacity continued during the year 2016, according to Danish Ship Finance market review (Christopher Rex, 2016). Crude tanker demand and product tanker demand increased by 3% and 4% respectively, whereas both crude and product tanker supply have increased each by 6% in 2016. Hence, the balance between tanker demand and supply has deteriorated during 2016. (Christopher Rex, 2016)

2.1.2 Outlook

Danish Ship Finance (Christopher Rex, 2016) concerns over the growth potential for seaborne trade volumes relate to fossil fuels due to the combined effects of renewable energy and its ongoing penetration of sharing economic principles into more and more industries. This is highly relevant for the shipping industry's outlook, since fossil fuels represent approximately 45% of annual seaborne import volumes, while Dry Bulk volumes (excluding coal) account for 34%.

According to Danish review (Christopher Rex, 2016) other factors affecting the rate of growth in seaborne trade volumes include digitization (i.e. the fourth industrial revolution), slower population and economic growth, greater efficiency and productivity, and the global economic shift toward services. Although many signals are negative for shipping, for instance the slowdown in China, the lifting of some sanctions on Iran is expected to stimulate crude oil trade.

Danish Ship Finance (Christopher Rex, 2016) anticipates that overcapacity, lower freight rates and lower secondhand prices will continue the next 2 years for crude tankers. Growth in trade volumes is expected to be moderate, while the Crude Tanker fleet is set to expand by more than 4% p.a. up to 2018. On the one hand, this growth in trade can be explained by the limited oil demand, which in the medium-term is expected to grow by an average of just 1% p.a. until 2021. This prediction in oil demand comes from an expected decline in oil intensity of the world economy in tandem with increasing efficiency and substitution of oil with other energy sources. On the other hand, regarding the Crude Tanker fleet surplus in supply, the fleet is young and growing, while the order book corresponds to 16% of the fleet which are scheduled to be delivered within the next 2 years. Few scrapping candidates remain, which means that young vessels will have to be scrapped to balance supply and demand. Hence, the crude tankers' overcapacity is expected to expand, whereas transport volumes will not be sufficient to employ the growing fleet and therefore is expected the Crude Tanker market to remain low during the next 2 years.

Similarly, a growing oversupply is expected by Danish Ship Finance review (Christopher Rex, 2016) in the Product Tanker market, surpassing demand in 2017 at least. This could mean continuous pressure on freight rates and ship values. In line with Crude Tanker fleet, the Product Tanker fleet is young, with only 12% of vessels older than 15 years, there are very limited scrapping candidates (older than 20-25 years) and the order book equals 12% of the fleet. The fleet is estimated to grow by 4% in 2017. Increased oil demand following the drop in oil prices led to a significant increase in trading activity for Product Tankers which raised freight rates and ship prices during 2015. Consequently, this resulted in high expectations of ship owners and excessive ordering of new vessels, far beyond the long term requirement for replacing older vessels. According to Danish Ship Finance review (Christopher Rex, 2016) demand for refined oil products, notably gasoline and diesel will be driven by non-OECD countries, in particular Asian countries, as the population continues to grow and more people enter the middle class. In addition, expansion of global refinery capacity by 8% in total over the next 5 years has the potential to employ a large number of Product Tankers. Subsequently, Product Tanker demand is projected by Danish Ship Finance (Christopher Rex, 2016) to increase by around 2% annually up until 2021. In conclusion, the gap between supply and demand in Product Tankers market is estimated to diminish, but it will not disappear.

2.1.3 Competition and Competitors

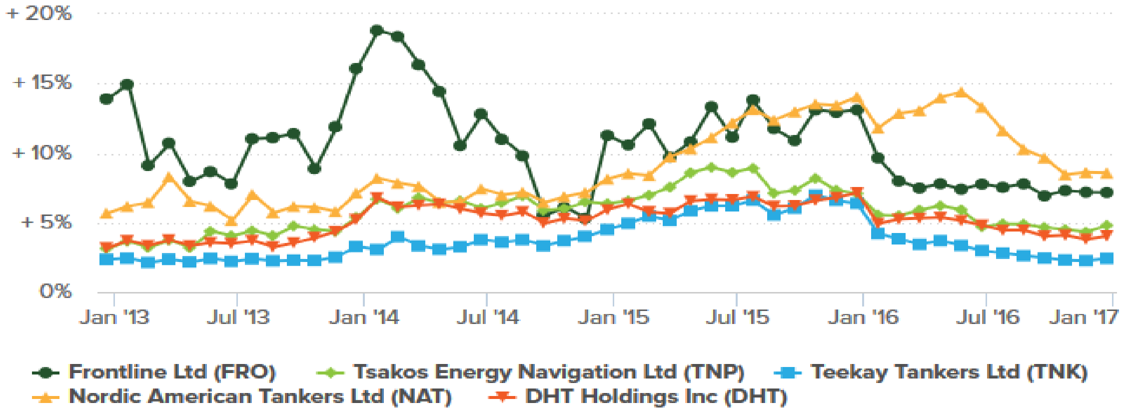
Shipping structure is characterized by fragmentation. On the one hand, there are a huge number of small family-run businesses that they control privately a large proportion of fleets, they are doing so for generations and they are particularly active in the tramp bulk[32] carrier and container feeder sectors. Strong examples can be found in Greece, the world's most important shipowning nation. Some of the family controlled businesses have funded their fleet expansions by accessing equity or debt in the capital markets; they have become corporations. Whilst their shareholders are public owners, family interests often remain strong. On the other hand,

[32] This includes dry bulk and liquid bulk cargoes.

multinational companies particularly active in bulk trades carrying their own cargoes and state-owned or semi-public enterprises control a substantial number of assets to serve their national interests. (Soare, 2015)

Prior to 1972, the major oil companies dominated every stage of oil industry including transport; they were the biggest tanker owners. Some economists argued that prior to the oil shock of 1973 the power of oil majors caused the tanker market to be oligopsonistic[33] in the sense that there were few but very large buyers. Others claimed that the market displays perfectly competitive behavior, despite the fact that oil majors dominated the ownership and the operation of tankers. After 1972, a new industry shaped where oil companies do not offer time charters as they used to, their fleets have halved and oil transport was outsourced to oil traders. Around 1990s, some economists believe that the short term tanker market works "very much according to perfect competition with very good knowledge of the market", which comes mainly from shipbrokers. Four big companies in the tanker industry had a concentration ratio of 17 % in 1995 and 21% in 1999 in European trades, compared with the 20% which is the typical competitive concentration ratio in theory. However, others at 2000s argued that in the long term they see a trend toward oligopoly in crude oil tanker carriage with competitive strategies likely to focus increasingly on differentiation, as the potential for operational cost-reduction fades. Nevertheless, the majority of maritime economists believe that oil tanker industry operates under perfect competition which presents several characteristics. These are the number of shipping service providers, the availability of information and the limited obstacles to entry and exit from the industry. There are a large number of ship owners that own tankers which provide identical shipping services. Shipping service providers are unable to manipulate the price (i.e. freight rate), because it is influenced by market fundamentals (i.e., demand for shipping service and supply of shipping service) and there are indicators of freight rates which provide information easily accessed such as Baltic Dirty Tanker Index for crude and Baltic Clean Tanker Index for product tankers. Entry barriers, such as government regulations, economic factors, and marketing condition, are not present in the tanker shipping industry. Although, huge capital investment is needed to acquire ships to enter the industry, shipping companies may withdraw from the market by selling their assets in the second-hand vessel sale and purchase market. (Y. H. Venus Lun, 2013)

Figure 25: Stock Performance of the top 5 oil tanker companies.



Source: Market Realist, BATS Exchange

Oil tanker industry is also fragmented and large competitors have acquired small market concentration. The total world fleet of VLCCs stood at 640 at the end of 2015. Out of these, only

[33] This is a market in which there are only a few large buyers for a product or service and they exert a disproportionate influence on the market.

56 VLCCs are operated by the top six[34] US listed oil tanker companies, which is merely 9%. The top six US oil tanker companies combined operate 79 Suezmax vessels out of the worldwide Suezmax fleet of 438. With regard to competitors' performance, the first quarter of 2016 was not favorable for oil tanker investors. All oil tanker stocks have given negative results. (Market Realist, Inc., 2016) Figure 25 indicates the downward trend in stocks of the five biggest listed in NYSE tanker competitors beginning from the start of 2016.

Table 6: **Top 30 tanker owners and operators.**

Rank 2016	Owner	DWT (in millions)	Company Type	Headquarters
1	Teekay Group	16,00	Public, listed NYSE	Canada
2	Mitsui-OSK (MOL)	15,00	Public, listed TYO	Japan
3	National Iranian Tanker Company (NITC)	13,50	Private	Iran
4	Euronav	12,90	Public, listed NYSE	Belgium
5	Bahri	12,80	Public	Saudi Arabia
6	AET	10,70	Private	Malaysia
7	China VLCC Company Limited[35]	10,50	JV state-owned	China
8	Frontline	10,40	Public in NYSE, OSE	Bermuda
9	Sovcomflot (SCF) Group	10,20	100% state-owned	Russia
10	Maran Tankers Management	9,50	Private	Greece
11	NYK Group	9,50	Public in TYO, NSE	Tokyo, Japan
12	China Ocean Shipping (COSCO Dalian)	8,80	State-owned	Beijing, China
13	Dynacom Tankers Management	8,50	Private	Greece
14	Ocean Tankers	8,02	Private	Singapore
15	China Shipping Development Corp (CSDC)	6,80	State-owned	Shanghai
16	Overseas Shipholding Group (OSG)	6,80	Public, listed NYSE	New York, U.S.
17	Maersk Tankers	6,00	Private	Denmark
18	SK Shipping	6,00	Private	South Korea
19	Minerva Marine	5,90	Private	Greece
20	Navios Maritime Group	5,90	Public, listed NYSE	Greece
21	Oman Shipping Co (OSC)	5,90	State-owned	Oman
22	BW Maritime	5,65	Private	Singapore
23	Gener8 Maritime	5,43	Public, listed NYSE	New York, U.S.
24	Thenamaris	5,37	Private	Greece
25	Tsakos Energy Navigation (TEN)	5,20	Public, listed NYSE	Greece
26	DHT Holdings	5,20	Public, listed NYSE	Bermuda
27	Formosa Plastics Marine Corp	4,50	Private	Taiwan
28	Shipping Corp of India (SCI)	4,50	State-owned	Mumbai, India
29	TORM	4,10	Public, listed	Denmark
30	BP Shipping	4,00	Private	UK
Total		**243,57**		

Source: Tanker Operator March 2016.

Table 6 presents the top 30 tanker companies worldwide based on their total fleet tonnage at the end of 2015, according to the Tanker Operator of March 2016. Most of the presented

[34] The top six crude tanker companies include Teekay Tankers, Tsakos Energy Navigation, Nordic American Tankers, DHT Holdings, Frontline and Euronav.

[35] This is a Joint Venture between China Merchants Energy Shipping (51%) and Sinotrans (49%), both China state-owned companies.

companies are private or public whose shares are traded freely on a stock exchange. Out of the total number of tanker companies, 12 are private, 12 are public and 6 are owned by government. In terms of deadweight, their share accounts for 44.4% of the total oil tanker tonnage (547.7 millions dwt, according to Clarksons at start of January 2016) and 14% of the global tonnage of 1.8 billion dwt at the start of 2016. Tonnage is well distributed between the top tanker owning companies, their stock performance are affected equally by freight rates which is an important indicator for where the market is and is heading. Hence, there are strong indications that the market is open and competitive since they cannot control the price and freight rates are shaping as a result of the balance of supply and demand and despite the fact that there are some concentrations of the large corporations in the market but not high enough to manipulate the market.

2.2 Global LNG and LPG fleet

LNG and LPG carriers are included in the specialized cargo fleet. The important point is that “specialization” is not just about the ship design; it is about adapting the shipping operation to the needs of a specific customer group and cargo flow. Setting up a specialized shipping operation is a major commitment because the ships are often more expensive than conventional bulk vessels, with a restricted second-hand market, and provision of the service generally involves a close relationship with the cargo shippers (Stopford, 2009). On the one hand, some cargoes such as chemicals and gas are more demanding to transport requiring special handling. On the other hand, some entrepreneurs see it an opportunity to differentiate their service by investing in these specialized ships and services.

The fleet of **LPG tankers** was about 1,000 LPG tankers in 2006 (Stopford, 2009), while the fleet evolved into 1,327 vessels as of January 2016 (Institute of Shipping Economics and Logistics, 2016), a 32.7% increase. LPG tankers fall into four segments. The big LPG tankers, called VLGCs (Very large petroleum gas carriers), over 60,000 cubic meters which are used on long-haul routes, especially from Middle East to Japan and from Trinidad and Tobago to Europe; the mid-size vessels of 20,000-60,000 cubic meters, used in medium-haul trades, particularly for transporting ammonia; and the smaller sized vessels of 5,000–20,000 cubic meters which are used in the short-haul trades, especially for the transport of olefins. There is also a sizeable fleet of very small vessels which are used mainly in the coastal and short-sea trades. The ownership structure of the VLGC fleet is highly concentrated, and there are LPG tanker pools[36] which play a significant part in the supply of LPG transport that prefer COA[37] or spot market contracts, but there are also independent operators who play the spot or time charter market. (Stopford, 2009)

The fleet of **LNG tankers** expanded from 193 ships with another 140 on order in 2006 (Stopford, 2009) to the total of 449 vessels at the start of 2016 (International Group of Liquefied Natural Gas Importers, 2016); it almost tripled over a 10 years’ period. It is a relatively young fleet; almost 63% of the vessels are younger than 10 years at the end of 2015, reflecting a newbuild order boom in the mid-2000s and again in early 2010s (Figure 27) (International Group of Liquefied Natural Gas Importers, 2016). Prior to the introduction of the Q-Class in 2008-2010, the standard capacity of the fleet was between 125,000 cm and 150,000 cm (International Gas Union, 2016). Currently, the cargo capacity of LNG tankers is focused between 90,000 and

[36] LPG tanker pools are groups of owners serving a specific market segment.

[37] Contract of affreightment is a contract between a shipping company and a shipper concerning the freight of a predetermined volume of goods within a given period of time and/or at given intervals.

170,000 cm, though in 2006, vessels almost twice this size was being built for the long-haul Middle East export trades. The Q-Flex (210,000-217,000 cm) and Q-Max (261,700-266,000 cm) LNG carriers that make up the Qatari Q-Class offer the largest available capacities. The Q-Class (43 vessels in total) accounted for 16% of the active tonnage at the end of 2015 (International Gas Union, 2016). LNG trade is limited (reasons explained in section 1) and not well developed. Following trade's expansion in 1990s, in particular quadrupled from 48 bcm in 1984 to 211 bcm in 2006, LNG fleet grew also at high rates during the aforementioned period. (Stopford, 2009) Although LNG carrier fleet owns a small number of vessels, as they are noticeable from figure 23, it holds more than twice the capacity of LPG carriers. That is because of the large size that LNG carriers are being built. In particular, LPG carriers were 1,327 with capacity 25.8 million cm as of 2016, whereas LNG carriers were only 443 having 64.6 million cm in terms of capacity.

The gas tankers transport liquefied gases at very low temperatures (see Figure 26), particularly LNG, LPG, and chemical gases such as ammonia and ethylene which must be liquefied for transport. These commodities may be transported by a COA, time charter or consecutive voyage charter. After raw material production of natural gas, transport is needed, often called primary sea transport, in order to be processed as feedstock or end up to consumers. LNG tankers carry natural gas from oil and gas fields to power stations, though small amounts go as a feedstock to chemical plants. LPG tankers carry butane and propane from oil and gas fields to petrochemical plants producing and exporting two main product groups, olefins[38] (which are chemical gases) and aromatics[39] (which are liquids). Secondary sea transport occurs as a result of both crude oil refinery and petrochemical processing. Subsequently, the crude oil products (LPG or liquid fuels), olefins and aromatics are shipped on in gas tankers. (Stopford, 2009)

Figure 26: **Major traded liquefied gas commodities.**

	Boiling point °C	Specific Gravity	Ship Type	Primary Markets
1. Liquified petroleum gas				
Propane	−42.3	0.58	LPG tanker	Feedstock & heating
Ethane	−88.6	0.55	LPG tanker	Feedstock & heating
Butane	−0.5	0.60	LPG tanker	Feedstock & heating
2. Chemical gases				
Ammonia	−33.4	0.68	LPG tanker	Fertilizer manufacture
3. Olefines				
Ethylene	−103.9	0.57	LPG tanker	Chemical feedstock
Propylene	−47	0.61	LPG tanker	Feedstock
Butadiene	−5	0.65	LPG tanker	Feedstock
Vinyl chloride monomer	−13.8	0.97	LPG tanker	Feedstock
Memo				
Methane	−161.5	0.48	LNG tanker	Electricity generation

Source: **(Stopford, 2009)**

2.2.1 Recent Developments on demand and supply

Examining **LNG tanker demand** and therefore LNG trade developments, estimates of Clarksons Research indicate that global gas trade increased by 3.5% in 2015. UNCTAD's maritime review (United Nations Conference on Trade and Developement, 2016) highlights that global natural

[38] Olefins are ethylene, propylene, and butadiene.
[39] Aromatics are benzene, toluene and xylene.

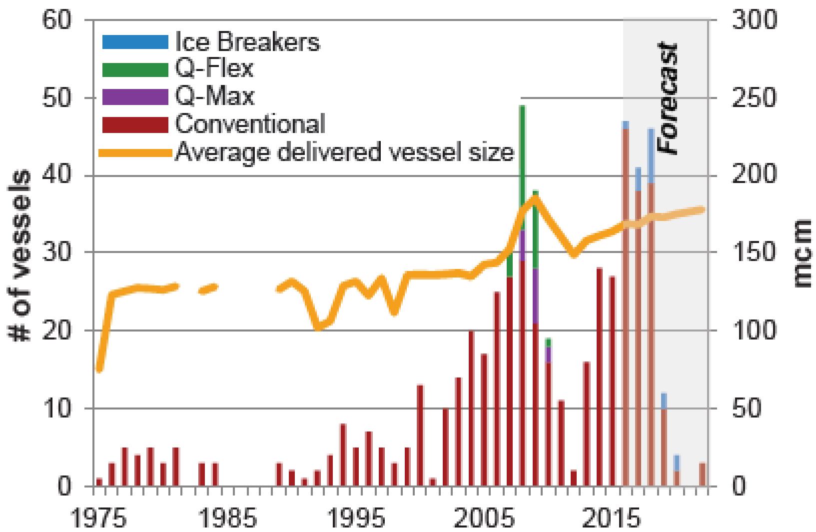
gas trade carried by sea in liquefied form expanded by 1.6% in 2015, down from 2.5% growth in 2014. However, global traded LNG volumes reached 338.3 bcm in 2015, a historical high for total trade in the LNG market, surpassing the previous post-Fukushima high set in 2011 by 330.8 bcm. Export growth was driven by Australia, Indonesia, Malaysia, Papua New Guinea and Qatar, while import demand was raised by Middle East, Europe and western Asia, i.e. China and India, as Japan is slowing its imports due to the ongoing substitution with nuclear power along with decreases in South Korea. Low LNG prices helped Middle East and Europe to see new countries (Egypt, Africa, Pakistan, Jordan and Poland), become LNG importers in 2015. In addition, United States increased its LNG imports by over 50%, while exports increased eightfold in 2015. Clarksons Research reported that in July 2015, 19 countries were exporting LNG and 16 countries have started importing LNG over the past 10 years (34 importing countries in total, according to GIIGNL). Moreover, instead of building onshore import facilities due to their high cost, alternative solutions appeared in 2015, including the use of LNG regasification carriers as mobile import terminals and floating storage and regasification units.

As regards the **LPG tanker demand**, UNCTAD's maritime review (United Nations Conference on Trade and Developement, 2016) mentions that trade in LPG is estimated to have expanded by 8.3% in 2015, owing to continued export growth in the United States and rising demand in the petrochemical and household sectors in Asia, notably in China and India. Danish Ship Finance (Christopher Rex, 2016) agrees that Asian economies continue to drive global LPG demand. In 2015, long-haul Asian imports from the US absorbed strong supply inflow, but when trade between US and Asia froze during the second half of the year, partly due to the declining demand of Asian petrochemical sector, signs of LPG oversupply started to emerge. The trade between US and Asia started again in 2016, but the fleet had grown quicker than demand. Global seaborne demand for LPG has grown approximately 9% in 2016. This growth is mainly driven by the China's petrochemical industry and strong household demand of South Korea and India. China is set on course to become the world's largest LPG importer with its imports estimated to have grown by 40% in 2016. Historically, Japan has been the world's largest LPG importer, but imports fell by 1% in 2016 and demand moderated over the past decade. Meanwhile, US exports increased by 30% in 2016 as result of rising naphtha prices (i.e. making LPG an alternative feedstock for the petrochemical sector), especially in Asia, declining freight rates and low US LPG prices.

On the **supply side**, although gas carriers represent only 3% of the total world fleet in terms of dwt of 2016, the highest growth (9.67%) was recorded for gas tanker fleet from 2015 to 2016 compared to the other fleet segments, according to UNCTAD (United Nations Conference on Trade and Developement, 2016).

ISL (Institute of Shipping Economics and Logistics, 2016) denotes that ***LNG tanker fleet*** grew by 7.1% in 2015 with 33 new LNG carriers of 4.9 million cm added to the total fleet. A recent trend for larger LNG carriers has increased the average capacity of the delivered vessels since 2012. Conventional carriers with capacities between 170,000 cm and 180,000 cm, known as New Panamax carriers, have become the new standard for newbuild LNG vessels after the expansion of Panama Canal in 2016. The inflow in capacity in 2015 far outweighed the shipping requirements from the additional volumes of LNG trade growth. Moreover, delays in the completion of new LNG projects as well as the shutdowns at Yemen and Angola LNG export terminals cut down demand for LNG trade. As a result, the existing oversupply in the LNG shipping market exacerbated, leading to a 49% fall in charter rates between January and December 2015 (International Gas Union, 2016). IGU mentions that estimated average spot charter rate for a dual fuel LNG diesel electric vessel fell to USD 27,000 per day in 2015, compared to 2013 when rates skyrocketed to USD 100,000 per day, triggered from 2011 Fukushima crisis. However, due to an unbalanced market between basins, spot charter rate for TDFE tankers were at times in 2015 around USD 40,000/day in the Atlantic Basin, yet ship-owners were hesitant to reposition their vessels owning to the risk of occupying them to a lower-volume market. The last decade, there has been an emergence of a spot LNG charter market at two district levels (see Figure 28); the older conventional *steam based vessel market*[40] and the younger *DFDE/TFDE vessel market*[41]. The former is associated with smaller capacity and higher operational costs often received lower rates, and the latter is associated with larger capacity and more efficient engines but in excess of maintenance cost. Both charter markets are affected by the newbuild boom that was not absorbed by LNG demand growth, thus overcapacity created, which in turn caused the fall in spot freight rates. Figure 28 depicts the above described situation in the LNG charter market with DFDE/TFDE segment to outperform its steam counterpart reaching historically higher spot charter rates. However, a growing number of recently delivered DFDE/TFDE tankers were forced to remain idle because of insufficient charter opportunities.

Figure 27: Global LNG Fleet by year of Delivery versus Average Vessel Size.

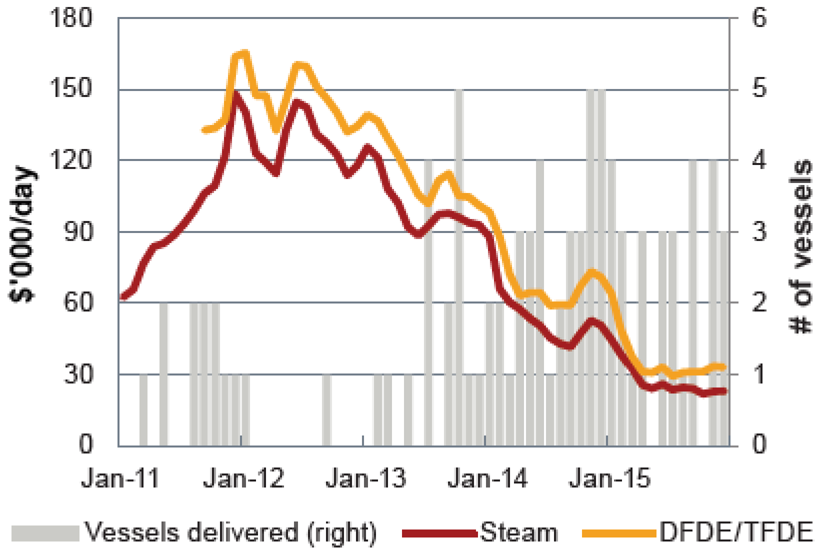


Source: IGU 2016.

According to IGU (International Gas Union, 2016) the pace of contracting newbuildings has drastically slowed down from second half 2014, in contrast to the previous years where there has been a substantial activity of new orders. In 2015, only 24 vessels have been ordered, compared to 2014 when orders skyrocketed to 68 vessels. At the end of 2015, 19 vessels (all conventional tankers with a capacity of under 150,000 cm) were laid-up, from which 80% approximately were over 30 years old. Only 3 vessels demolished and 4 vessels were flagged for conversion as floating storage units during 2015, out of 36 vessels older than 30 years, equal to 8% of the existing LNG fleet (International Group of Liquefied Natural Gas Importers, 2016).

[40] Steam turbines are the traditional propulsion system of LNG carriers, which they necessarily burn cargo during voyage.
[41] DFDE stands for Dual-Fuel Diesel Electric propulsion and TFDE stands for Tri-Fuel Diesel Electric propulsion. They improve vessel efficiency by around 25-30% over the traditional steam-turbines.

Figure 28: Average LNG spot charter rates versus Vessel Deliveries, 2011-Dec 2015.



Source: IGU 2016.

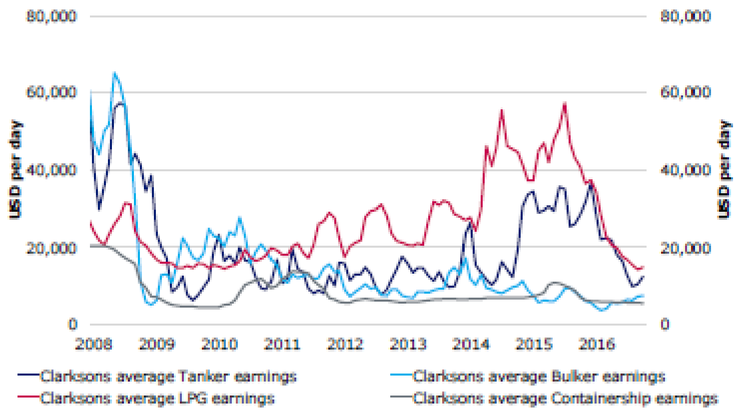
Danish Ship Finance (Christopher Rex, 2016) declares that ***LPG carrier fleet*** grew almost by 17% in terms of dwt in 2015, a record high in deliveries. ISL (Institute of Shipping Economics and Logistics, 2016) points out that at least 83 LPG carriers delivered in 2015 with a combined capacity of 3.6 million cm. Danish Ship Finance (Christopher Rex, 2016) highlights that the LPG fleet expanded by 16% the first ten months of 2016 and it is expected to reach 19% at the end of the year. Fleet growth is powered mostly by the VLGC segment which increased by 20% (41 vessels). This second year record-high has pushed the LPG fleet ahead of demand and freight rates alongside with earnings have been declining accordingly (see Figure 29). VLGC spot rates more than halved during the second half of 2015 and they have halved again during 2016. Particularly by November 2016, the average spot rate for a VLGC was 65% lower than in 2015. Seasonal uplifts in spot rates at the end of the petrochemical plant maintenance (late spring, early summer) and at the start of the winter months did not materialize, because of the large number of vessels being currently in the market. In tandem with spot rates, time charter rates have also been declining in 2016 pressured by the fleet additions. Notably, the 1-year VLGC time charter rate has dropped by more than 65% since the start of 2016.

Danish Ship Finance (Christopher Rex, 2016) reported that the majority of LPGs (84%), along with Product Tanker orders, was delivered on schedule in the first ten months of 2016. The persistent decline in freight rates throughout 2016 created strong incentives to postpone or even cancel deliveries. However, vague optimism is visible in the tanker segments when comparing their delivery performance with the different market segments (see figure 30). In addition, despite the decreasing freight rates, scrapping was limited during 2016. Only nine vessels were scrapped within the year, out of a stock of 57 vessels older than 25 years, equal to 6% of the delivered capacity. The average scrapping age was 32 years, ranging from 27 to 38 years.

Further consequences of the overcapacity and the decreasing freight rates in the LPG tanker market have been the limited contracting activity of newbuilding orders, after record ordering in 2014, and the reduced by 20% second-hand and dropped by 10% newbuilding values in 2016, as states Danish Ship Finance (Christopher Rex, 2016).

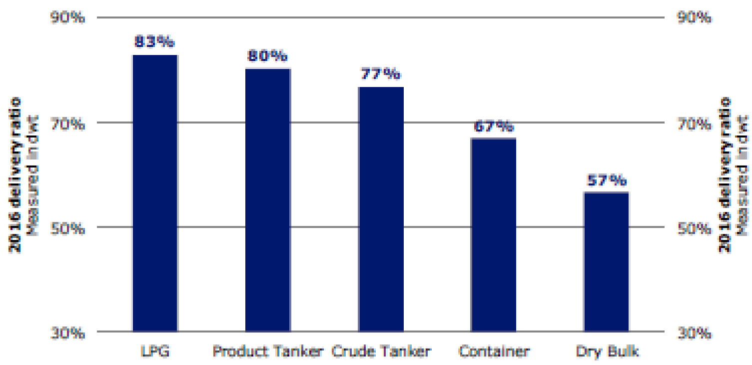
In short, ISL (Institute of Shipping Economics and Logistics, 2016) highlights that LPG market showed exceptional strength during 2015, whereas LNG market remained at low levels since mid-2015. The transported LPG/LNG volumes reached 327 million tons in 2015, while in 2016 recorded approximately 339 million tons due to the development of new offshore gas fields. The global oversupply of LPG has caused the price spread between regions to narrow and turned the market from being demand-driven to supply-pushed (Christopher Rex, 2016). Similarly, in the LNG market, oversupply of LNG has put pressure on the LNG prices and transformed the market. Supply factors led to the current cycle, though in the past years LNG demand factors drove orders. The LPG/LNG fleet together comprised a capacity of 90 million cm as of 2016 and featured the highest tonnage growth in a 4-year period of 2012-2016 within the total tanker fleet (see figure 23). This fleet segment expanded by 5.6% on average annually for the last 4 years, as opposed to the crude oil and oil product tankers growth which accounted for 2.1% p.a. at the same period. The supply and demand gap in the LPG tanker market has continued to widen in 2016.

Figure 29: Average LPG and Tanker earnings dropped by more than 50% since the start of 2016.



Source: **(Christopher Rex, 2016)**

Figure 30: Delivery ratio of 2016-Various market segments.



Source: Danish Ship Finance **(Christopher Rex, 2016)**.

2.2.2 Outlook

Global climate action agenda, advances in renewable energy and energy storage could affect end-user gas demand and shape tanker trade patterns, according to Danish Ship Finance (Christopher Rex, 2016). UNCTAD projects that gas as a more environmentally friendly alternative to oil and coal implies that trade in LNG may be expected to benefit, at least in the short and medium terms, mainly from effects associated with global climate change action. Furthermore, the expansion of Panama Canal could shorten travel distances for long-haul routes and consequently benefit LPG trade between US and Asia, as vessel supply will be more efficient.

Danish Ship Finance (Christopher Rex, 2016) predicts that low freight rates and secondhand prices are expected to continue the next 2 years for *LPG tankers*. However, limited placement of new orders and steady growth in LPG demand could lead to a market recovery beyond 2018. On the demand side, LPG trade volumes are expected to grow by more than 5% per year over the next 5 years. This growth is lower than the previous year but growth rate will be steady. It is expected that Asia will remain the main driver for seaborne LPG trade. Based on IEA's predictions, providing that US shale oil production will continue to grow in the next years (LPG accounts for a large part of the retrieved shale oil volumes), US LPG exports would be boosted. However, increased LPG exports from US do not necessarily mean higher demand for seaborne LPG transport[42]. As regards the supply forecasts, the order book currently equals 22% of the fleet, indicating significant expansion over the next 3 years. At the same time, scrapping potential is limited, as only 5% of the fleet is older than 25 years. They consider it unlikely that freight rates for VLGCs and MGCs will remain stable without significant scrapping, including younger vessels, as it will be difficult for demand to absorb all incoming vessels. However, Danish (Christopher Rex, 2016) remarks that if contracting remains at low levels and owners scrap vessels prematurely the balance between demand and supply could begin to recover during 2018. (Christopher Rex, 2016)

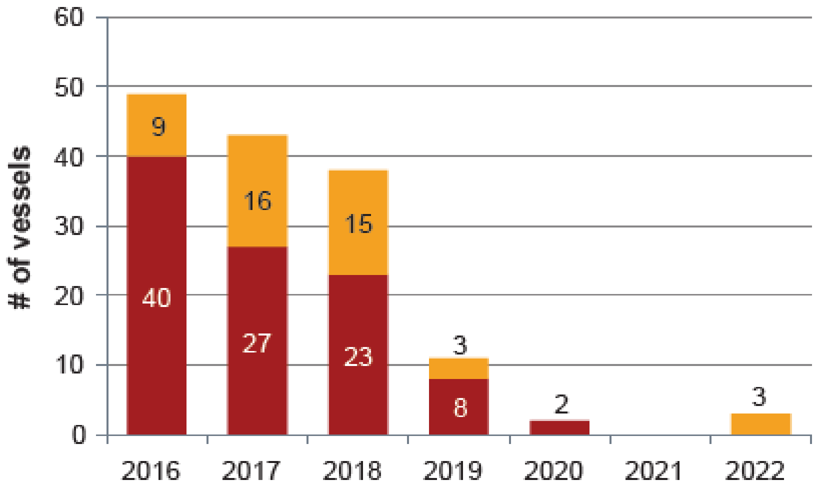
Regarding *LNG tanker* demand, LNG trade[43] is expected to dominate global gas long-distance trade; its share is set to increase to 53% by 2040 at the expense of pipeline according to IEA estimations (see figure 22). However, LNG's share of global gas trade was 32% in 2015. The largest global flow route is Inter-Pacific trade[44], accounting for 39% of all global trade. IGU (International Gas Union, 2016) projects that Intra-Pacific LNG trade flows will expand over the next 2 years, as significant new export capacity of Australian projects is set to come online in the Pacific Basin. In addition, starting in mid-2017 and beyond, the additional US capacity will start to balance the expected Pacific push with more flexible Atlantic supply. Asia will likely remain the primary driver of LNG demand growth, despite the several signs of weakness showed in 2015. Nuclear restarts in Japan and prolonged economic weakness in China are potential negative factors for the outlook of LNG trade. IGU (International Gas Union, 2016) expects that the LNG market is likely to be enriched with new flexible supply, as other proposed countries may add import capacity; if the downward pressure on prices continues, driven by weak demand. The price of LNG is one of the main driving forces of demand. Debbie Turner (Thomas, 2017) expects that there will be more competition from new volumes of LNG in 2020, enforced by US exports, Australia and Russia's Yamal, as LNG price refrain from oil-indexation. The increased trend of LNG contracts having shorter terms and destination restrictions will add market flexibility. Drewry expects LNG tonne-mile growth to average 8% annually in 2017-2020, thus LNG carrier demand will also grow. Therefore, Drewry believes that rates will improve from next year.

[42] Danish report (Christopher Rex, 2016) analyses, "increasing LPG exports could potentially narrow the price gap between export and import regions to such an extent that arbitrage windows become unworkable and seaborne transportation demand stagnates".

[43] LNG trade outlook is also examined in more detail in Section 1.3, Oil and Gas Demand.

[44] Historically, Inter-Pacific trade was much higher; over 70% in the early 1990s, but supply from Qatar and other Middle East and Atlantic suppliers diminished its share to hit a low of 34% in 2012.

Figure 31: **Estimated Future Conventional Vessel Deliveries 2016-2022.**



Source: IGU 2016.

On the supply side, the trend for larger LNG vessels continues on the new placed orders. Based on the current order book, the average ship capacity is set to increase to 175,000 cm (+7%) by 2020, compared to 164,000 cm in 2015. IGU (International Gas Union, 2016) expects that oversupply will persist given the additional tonnage. Many LNG vessels ordered in 2012 and 2013 having no contract at the time of the order, as a result 46 vessels today remain unchartered. 146 LNG carriers comprised the order book as of January 2016, representing approximately 40% of the current fleet; their expected delivery is described at Figure 31. Moreover, a new innovation in LNG carrier engine design, the ME-GI[45] engine, may potentially create a three-tiered charter rate market, instead of the current two-tier system, as the global fleet becomes more diverse. Around 37% of vessels in the order book are designated to adopt the ME-GI innovation. IGU projects that the surplus in supply of tonnage is likely to continue until the turn of the decade, as the liquefaction capacity is set to increase by nearly 50% by 2021, particularly from US Gulf Coast, leading to additional demand for LNG tonnage.

2.2.3 Competition and Competitors

Stopford (Stopford, 2009) states that shipping companies who provide services by transporting specialized cargoes require appropriate management structure and proven specific-sector expertise which acts as a barrier to entry the specific market segment, often leading to a higher concentration of ownership. As a result pools and cooperative arrangements are more common in the transport of specialized cargo, such as gas. For example, a shipping company transporting gas is a vital link in oil and gas industry value chain, resulting companies to diversify their activities in more than one part of industry chain. BP's business not only includes upstream and downstream operations, but also deploys its own tanker fleet.

Pools are frequently used in most shipping market segments, but had yet to be employed in the LNG arena. However, in August 2015 an LNG tanker pool was created by Dynagas, GasLog, and Golar LNG with purpose to help their vessels which are trading on the spot market. The pool was developed as the low charter rates were causing recently delivered vessels to remain idle. Dynagas manages the "Cool Pool", as it is referred to, and focuses on charter durations of 12 months or less, with 14 tankers to participate in the pool. The pool aims to increase operational

[45] M-type, Electronically Controlled, Gas Injection (ME-GI) engines optimize the capability of slow speed engines by switching to burn gas or fuel oil when necessary. This allows for better economic optimization at any point in time, particularly a 170,000cm ME-GI vessel may consume 15-20% less than a same vessel with a TFDE propulsion system.

flexibility to owners, efficiency of the combined fleet, spread the risk, stabilize the income stream, resulting in the end to have more influence on the charter rates, as it controls a larger share of the shipping capacity. (International Gas Union, 2016)

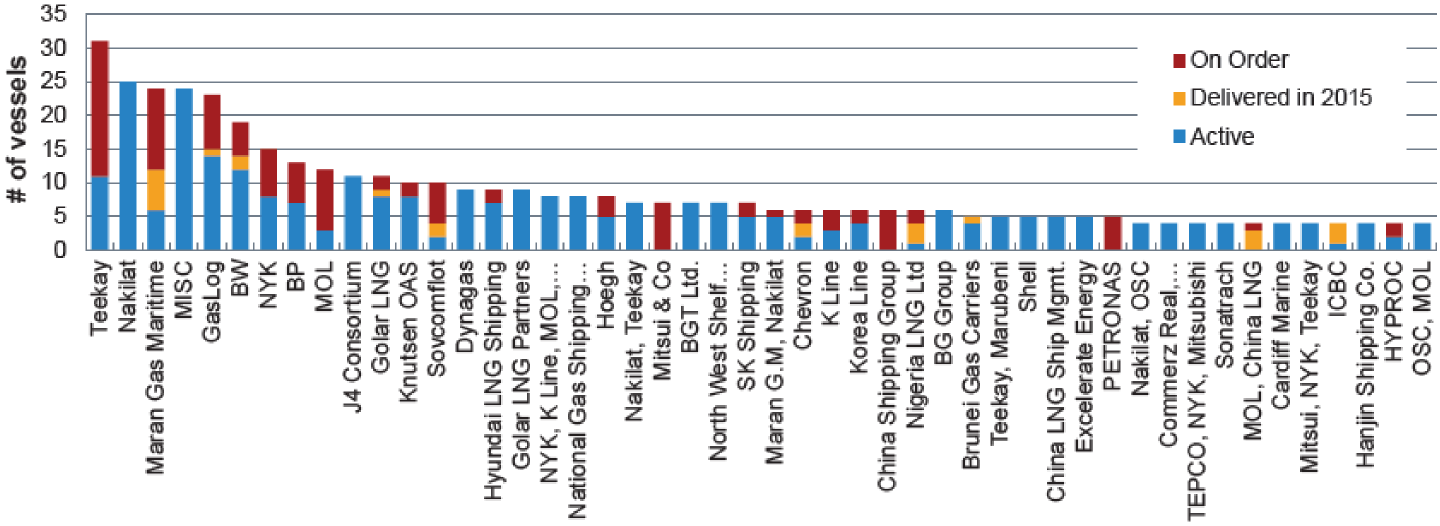
Traditionally, LNG shipping was part of a business whose entire supply chain was controlled either often from a state-owned monopoly or an international gas company. After 1990s, the business evolved to a heterogeneous supply chain in which shipping has obtained independent status. Nowadays, as part of the global trend of privatization in the energy markets started from US and UK, ongoing deregulation and liberalization are taking place in the LNG market in both upstream and downstream levels, moving towards a gas-to-gas competition. The wave of new entrants since the expansion in the LNG market during the last decade has changed its structure from oligopolistic to a more competitive one. However, a great number of cooperation agreements and consortia are developing. More and more independent ship-owners are cooperating with upstream gas sellers by investing in liquefaction plants and an emerging trend evolves, of converting ships to floating gas storage or regasification units. Although, the dominance of a few large buyers or state monopolies is losing ground, most key gas-rich countries in the Middle East, such as Qatar, still hold a national LNG fleet and control much of the upstream and downstream business. (Steve Engelen, 2010) In 2016, vertical integration still exists; out of the 100 vessels on charter in the order book, 35% are tied to companies that are considered an LNG producer and a third of them are driven by LNG buyers.

LPG tanker pools play a significant role in the supply of LPG transport, but there are also independent owners trading on the spot or time charter market. The ownership structure of the VLGC fleet is highly concentrated. For instance, Bergesen, one of the largest owners of LPG tonnage, operated the VLGC pool which in 2003 included ships owned by Exmar, Mitsubishi, Yuyo Ship Management, Neste Sverige and Dynergy. (Stopford, 2009)

Contrary to the LNG market, ownership patterns in the LPG market show similarities with the crude and product tanker markets because they do not operate in such level with long-term agreements. State ownership has declined over time and many players are incumbents. In 2009, 13% out of 140 VLGCs were publicly owned, while traders and oil companies controlled 18% of the total VLGC market via long-term contracts. However, typical asset players do not exist in the gas markets as those in the tanker and dry bulk market. That is because transactions are not enough to engage in asset play as well as they lack liquidity. Shipping companies often cross-subsidize their gas carriers with cash earned from other freight markets, since contracting happened in a speculative basis, as they were not able to repay the expensive building price with low freight earnings. Consequently, utilization of LPG carriers is lower than in the more liquid markets of tanker and dry ships. (Steve Engelen, 2010)

In the maritime industry, there is a consensus that second-hand ship values are shaped in tandem with freight rates. High freight earnings will cause higher second-hand prices, in turn increased demand for contracts which will boost newbuilding prices. Newbuilding prices are rather determined on the global market as a result of yard utilization levels and overall contracting levels. However, the above correlation do not apply in the gas market, as high contracting of LPG vessels will not impact newbuilding prices because the gas market is relatively small and lacks liquidity. Correlation between earnings and second-hand prices is not confirmed as well in the gas market, but only holds in the larger and liquid merchant markets. Freight rates fluctuate as a result of demand and supply balance. In the gas shipping market, however, freight earnings are shaped by the gas freight market itself. Consequently, the above conditions set barriers in free entry and exit of participants. Entering the market is difficult, because there is not established second-hand market, while exit is difficult as purchase candidates will prefer newbuildings if the second-hand price is not advantageous. (Steve Engelen, 2010)

Figure 32: LNG Fleet by respective company share.



Source: IHS

2.3 Price formation, factors and transport costs

Shipping contributed to the global trade evolution by making the cost of freight so small, representing only a small proportion of the total value of world trade, therefore sea transport cost is not anymore a major issue in deciding where to source goods. In fact, oil cost little more to transport in 1990s than 50 years earlier. In 1949, the shipping cost was $0.50 per barrel, while during the 2004 boom the cost went up to $3.37 per barrel. However, Stopford (Stopford, 2009)emphasizes that compared to the other sectors of economy, shipping business achievement was to maintain costs low when the cost of commodities it carried increased by 10 or 20 times. As a result, shipping freight for many commodities is now a smaller percentage of costs than it were 30 years ago. Stopford (Stopford, 2009) supports that this cost performance was succeeded by a combination of economies of scale, new technology, better ports, more efficient cargo handling and the use of international flags to reduce overheads.

Economies of scale played a major role in keeping sea transport costs low. Over the years, average size of ship in each shipping segment tends to increase. Generally, shipping firms face three categories of costs: capital cost, running cost and voyage cost[46]. Stopford (Stopford, 2009) examines the unit cost function which explains why investors go for bigger ships. He refers that *"the unit cost of transporting a ton of cargo on a voyage is defined as the sum of the capital cost of the ship (LC), the cost of operating the ship (OPEX) and the cost of handling the cargo (CH), divided by the parcel size (PS), which for bulk vessels is the tonnage of cargo it can carry"*

$$\text{Unit Cost} = \frac{LC + OPEX + CH}{PS}$$

The unit cost decreases as the vessel size increases because capital, operating and cargo-handling costs do not increase proportionally with the vessel

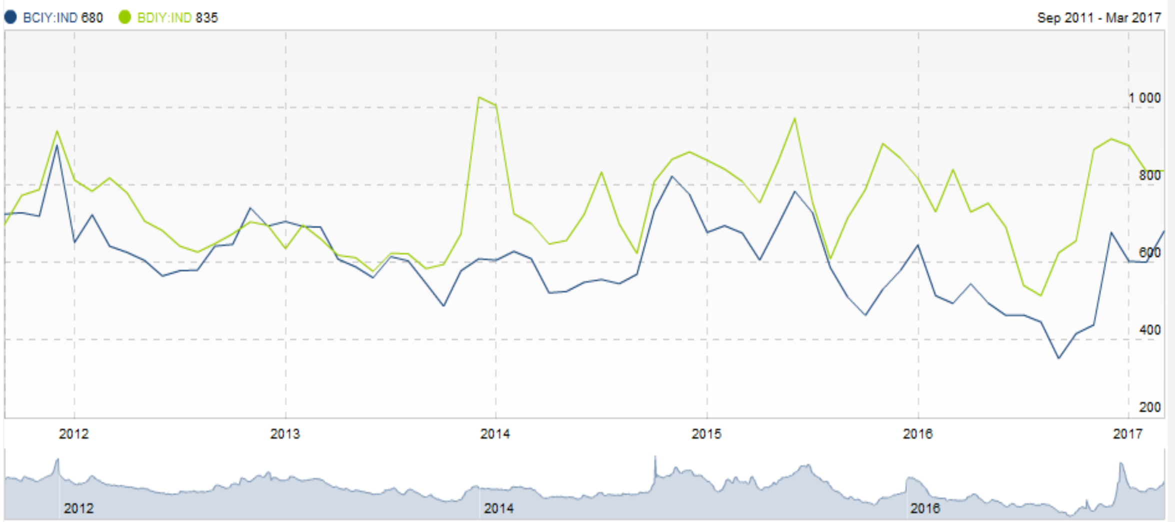
[46] These costs are shared differently between the charterer and the ship owner under different charter agreements. With a voyage charter, the ship owner bears all three costs. With time charters, the ship owner bears capital cost as well as running cost, while the charterer covers voyage cost. Whereas in bareboat charters, the ship owner bears only the capital cost, with all other costs being borne by the charterer.

tonnage. For instance, a 330,000 dwt tanker costs twice as much as an 110,000 dwt, but it carries three times as much cargo, so the cost per oil ton transported in an 110,000 dwt vessel is much higher than in a 330,000 dwt ship. (Stopford, 2009)

Ship transport costs are driven up and down by the freight market. When economic conditions or random shocks change the outlook of the global trade, it takes time for the shipping industry to adjust; by either altering the capacity of ships in service or producing new ones. As a result, shipping costs are volatile, as indicated in figure 33. Furthermore, tanker shipping costs are seasonal because demand for crude and product tanker service is seasonal. Thus, it is sensible to compare tanker shipping costs' year-over-year performance. For example, on September 2016 Baltic Tanker Indices were on average 17% lower than in the same period in 2015. There were large increases on tanker freight prices in 2014, as falling crude oil prices in mid-2014 led to surging shipment volumes. Prolonged period of low crude oil prices over the next years, helped in a market situation called "contango[47]", which created high incentives for oil storage. Hence, increased demand for tankers continued. However, fleet overcapacity counteracted the further increase of tanker shipping prices.

The last decade, the gradual decline in the cost structure in the entire LNG chain[48] has enable LNG to compete with piped gas. Logistic costs of liquefaction activities have reduced three times in half during 1980-2005, mostly due to decline in capital costs to set up the LNG plant. Technological advance has brought down costs in the LNG value chain. LNG liquefaction and regasification terminals have increased in capacity in tandem with the LNG ship size. Competition among shipyards reduced substantially (45%) the construction cost of LNG tankers during 1995-2005. (Steve Engelen, 2010)

Figure 33: Shipping prices (Baltic Dirty and Baltic Clean Tanker Index)



Source: Lloyd's List

Gas can be transported either by pipeline or as LNG. Which is the most economic way of transporting gas? On the one hand, the cost of transported gas by pipeline is directly proportional to the distance. For short distances, pipeline is preferred. However, as the distance increases, the cost of transporting gas by pipeline escalates rapidly. Another key factor constitutes the dimension of the pipeline. The cost of the pipeline increases as a function of the

[47] Spot price is lower that forward price.

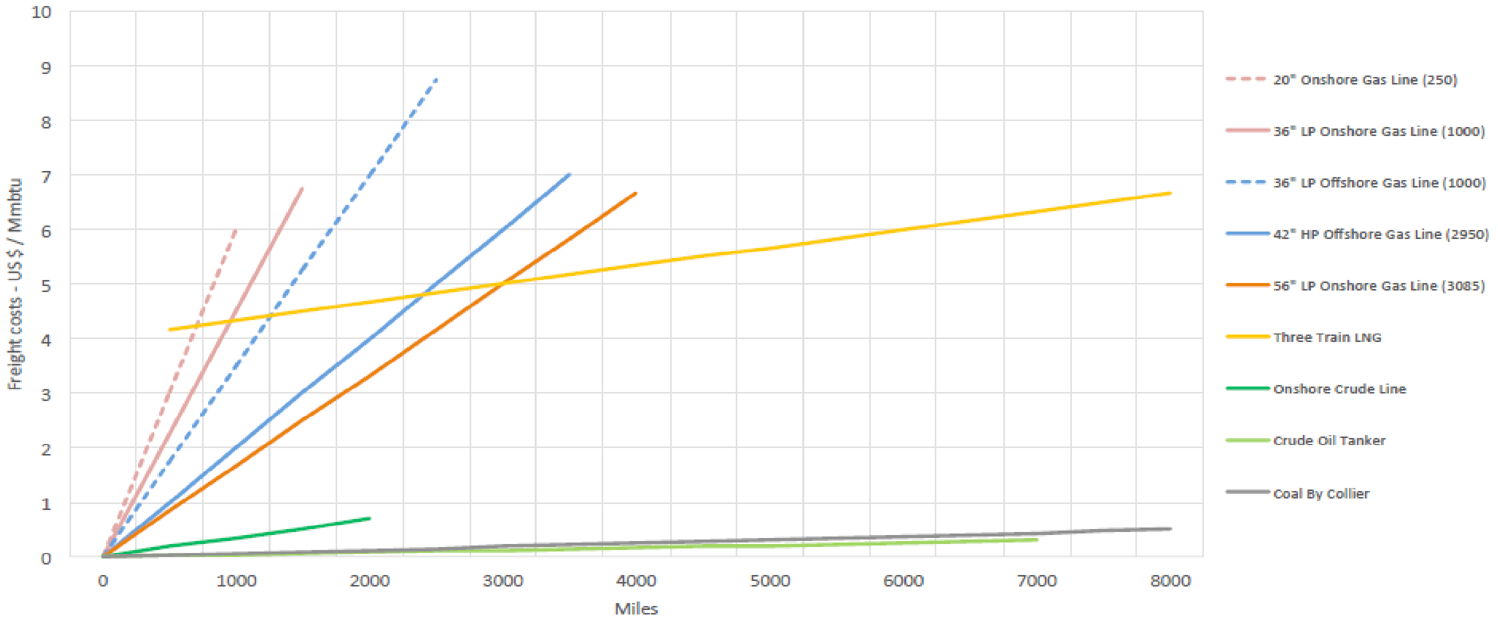
[48] A LNG chain is composed of exploration and production of natural gas, a liquefaction plant, a set of LNG carriers and storage and a regasification plant.

diameter of the pipe, while the volume of transported gas increases as a function of the square of the diameter. On the other hand, LNG is more competitive for longer distances; in contrast to pipeline it becomes uneconomical for short distances, as the liquefaction cost constitutes a fixed cost at the beginning, approximately 4$/Mmbtu as shown at figure 34. (Luciani, 2016)

Particularly, oil can be transported from short to very long distances (7,000-8,000 miles), while the cost slightly increases, as it is illustrated at Figure 34. In the case of gas, freight cost accelerates quite rapidly, especially for small diameter pipelines, before even reaching 1,000 miles. Larger pipelines allow gas to be transported over significant distances of close to 3,000 miles and they are still competitive over LNG. However, for distances exceeding 3,000 miles, essentially LNG constitutes the only solution, as for the cases of island countries, such as Japan. This explains the predominance of Japan as the larger LNG importer globally, because there is no other economic alternative. Although, there is a substantial initial cost of almost 4$/Mmbtu, the increase in the cost of LNG is much slower than pipeline, as gas is transported over long distances.

A world gas conference report (Sylvie Cornot-Gandolphe, 2003) refers that besides economics there are three elements which have favored LNG versus pipeline. The size of investment, utilization and market size and it also states that financing of LNG has lower risk. Investment costs for pipelines are mainly focused to an increase in capacity that is difficult to absorb by the market. LNG is more attractive than pipeline gas even at much shorter distances (from 2,000 to 4,000 km), it is preferred for smaller projects which fit better in markets that start with small demand. Finally, there are striking examples from Middle East and Asia Pacific where though pipe option should be certainly the more economic option for intra-regional gas trade, political and geographic considerations have impeded this development and favored LNG option. (Sylvie Cornot-Gandolphe, 2003)

Figure 34: **Transport 2011 costs for gas, oil and coal. Showing gas' higher costs and the effect of scale**
(Gas delivery capability in million cubic feet per day)



Source: Jensen Associates, **(Luciani, 2016)**

In conclusion, shipping costs are indicated by freight rates which are the source of ship-owners' earnings. Over the decades, transport costs are declining compared to the value of goods they carry. Freight rates are influenced by many factors (will be further examined in upcoming section 4) among which the world economy, random shocks, seasonality of seaborne commodity trades, average haul, transport costs, changes in shipping technology, economies of scale in ship size as well as ship specialization, according to Stopford (Stopford, 2009) and Lundgren (Lundgren, 1999). Additionally, LNG is economically viable over long distances in contrast to pipelines which are mostly built for distances below 3,000 miles. Pipelines also face technical, geographic and political limitations, except for economic constrains. They have a maximum limit in export capacity and they are subject of conflicts between transit and neighboring countries, as explained in previous section (Geopolitics of natural gas, section 1). Thus, in case of unpredicted disruptions or decline on the supply and demand side there is no alternative route, compared to LNG which offers "destination flexibility".

2.4 Major ports - International transport routes

Today cargo moves between more than 3,000 major commercial ports. Maritime trade is dominated by three economic centers, Europe, North America and Asia. Western Europe's mature economy accounted for 23% of world seaborne imports and exports back to 2005, with European companies to play a leading part in the shipping industry, owning 42% of the total world fleet. Asia region (including Japan 7%, China 9% and South & East Asia 16%) accounted for 32% of the total seaborne trade in 2005, with much of the trading activity to be clustered in the area between Singapore and Japan. North America, which includes Canada and the USA, is following with 12%, a mature economy with a need to import raw materials such as oil and manufactured goods. Middle East, Central Asia and Russia are marginal suppliers of oil and gas. Middle East, as the largest oil exporting area, held a seaborne trade share of 9% in 2005. (Stopford, 2009)

According to data from Eurostat, ***in Europe*** the largest volumes of liquid bulk cargoes in 2015 were handled in the Netherlands (278 million tons), followed by the UK (194 million tons) and Italy (186 million tons). The most specialized ports in handling liquid bulk goods were Bergen in Norway (43.5 million tons), Botas in Turkey (78 million tons) and Trieste in Italy (57 million tons).

In USA, important oil terminals constitute port of South Louisiana which handled 235 million tons of total cargoes in 2015, port of Houston in Texas (218 million tons), port of New Orleans recorded almost 80 million tons and port of Corpus Christi almost 78 million tons, according to data from (U.S. Department of Transportation, 2016) Annual Report of 2016 and AAPA. Louisiana Offshore Oil Port (LOOP) is the nation's first and only deepwater oil terminal capable of handling VLCCs (Stopford, 2009). Louisiana has five natural gas marketing centers, the most active being Henry Hub. In February 2016, the Sabine Pass liquefaction plant and tanker terminal opened, giving Louisiana the first large-scale LNG export terminal. Gulf Gateway Energy Bridge Deepwater Port constitutes Louisiana's and world first deepwater LNG import facility. Valdez is the northern US export terminal which handles Alaskan crude oil. In Canada, some oil cargo volumes are shipped through San Francisco and Los Angeles, but their main trade is container traffic. (Stopford, 2009) Last but not least, South America countries though having smaller economies than North America's, there is significant oil export trade of Mexico through port of Coatzacoalcos on the southern Gulf, which is the focal point for the seven major oilfields of Mexico. (Stopford, 2009)

In Asia, trading areas are split into Japan, China and southern and eastern Asia being all net importers of energy. In terms of cargo handled in 2015 the major Japanese ports include Yokohama, Kobe, Nagoya, Osaka and Tokyo. Yokohama (114 million freight tons), Nagoya (197 million freight tons) and Tokyo (85 million freight tons) constitute important cargo centers of crude oil and liquefied natural gas. China's biggest ports out of 40, in terms of cargo tonnage, are Shanghai, Qingdao, Guangzhou, Ningbo, Tianjin and Dalian, all at the 10 first ports globally as showing Table 7. Although Shanghai with 646 million tons overall is the world's largest port in terms of volumes in 2015, it is China's center for containers. Oil is mainly shipped in through Qingdao, Huangpu, Xiamen and Tianjin. In addition, Dalian is an important petroleum port and a major center for oil refineries, diesel engineering and chemical production. Singapore and Hong Kong are two largest container ports of South and East Asia. Singapore is the world's second busiest port in terms of cargo tonnage; it is the third busiest petrochemical refinery in the world and transships half of the world's annual supply of crude oil. The major ports of South Korea are Busan, Kwangyang, Ulsan and Inchon. The port of Ulsan is home to the biggest shipyard, Hyundai Heavy Industries, and constitutes the world's second largest oil refinery. It is the country's hub of liquid cargoes, handling more than half of South Korea's crude oil imports. Port of Inchon handles a significant amount of liquid bulk cargo, having oil and liquid terminals specialized in handling oil, liquefied petroleum and natural gas. (Stopford, 2009) (Waters, 2005)

The economies of ***Middle East, central Asia and Russia*** depend heavily on the export of crude oil. King Fahad Industrial Port in Yanbu, Juaymah and Ras Tanura terminals are the major ports and terminals of Saudi Arabia for the export of crude oil, refined petroleum products, and petrochemicals. Russia's most important ports are Primorsk, Ventspils, Murmansk and Novorossiysk, from which crude oil is exported. (Stopford, 2009) Port of Aden in Yemen served BP as an oil refinery and tanker port since 1970. Kharg oil terminal, a major export terminal of Iran, handled about 90% of nation's crude oil exports in 2015. Basra is Iraq's main port and Al Başrah along with Khor Al Amaya Oil Terminals provide the principal points of export for more than 80% of Iraq's GDP as of 2009. Port of Baku, the biggest and busiest port on the Caspian Sea, also capital of Azerbaijan, has developed an economy based on oil industry. Baku's oil terminal handles oil from Azerbaijan, Kazakhstan, and Turkmenistan that is destined for ports on the Black Sea and the international market. The port of Shuwaikh is Kuwait's most important port. Qatar has three main crude oil export terminals; Ras Laffan, Umm Said, and Halul Island. The Port of Ras Laffan is a deep-water port owned by Qatar Petroleum and it operates the world's biggest LNG export facility. Together, revenues from oil and natural gas amount to 60% of the country's GDP. UAE has several modern ports including Jebel Ali and Rashid which are both man-made. Port Khalid and Zayed, a deepwater port of UAE, handle significant amounts of liquid bulk cargo. (Waters, 2005)

Table 7: World Port Rankings 2015.

TOTAL CARGO VOLUME (TONS, 000s)				
RANK	PORT	COUNTRY	MEASURE	TONS
1	Shanghai	China	Metric Tons	646.514
2	Singapore	Singapore	Freight Tons	575.846
3	Qingdao	China	Metric Tons	476.216
4	Guangzhou	China	Metric Tons	475.481
5	Rotterdam	Netherlands	Metric Tons	466.363
6	Port Hedland	Australia	Metric Tons	452.940
7	Ningbo	China	Metric Tons	448.828
8	Tianjin	China	Metric Tons	440.430
9	Busan	South Korea	Revenue Tons	347.713
10	Dalian	China	Metric Tons	320.658
11	Kwangyang	South Korea	Revenue Tons	272.007
12	Hong Kong	China	Metric Tons	256.488
13	Qinhuangdao	China	Metric Tons	246.550
14	South Louisiana	United States	Metric Tons	235.058
15	Port Kelang	Malaysia	Metric Tons	219.786
16	Houston	United States	Metric Tons	218.575
17	Antwerp	Belgium	Metric Tons	208.423
18	Xiamen	China	Metric Tons	200.500
19	Nagoya	Japan	Freight Tons	197.947
20	Shenzhen	China	Metric Tons	191.037

Source: American Association of Port Authorities

Table 7 presents the world's busiest ports by cargo tonnage as of year 2015, the most fundamental measure of port and terminal throughput. Cargo tonnage includes the weight of dry bulk and liquid bulk cargo, break-bulk cargo, roll-on/roll-off (Ro/Ro) vehicles, and the contents of shipping containers.

Danish Ship Finance review (Christopher Rex, 2016) highlights that crude oil tankers in 2015 (measured in billion ton-miles) routed their cargo mostly to Asia, with their shares of the total crude tanker trade to be as follows

- Middle East to Asia: 36%
- Africa to Asia: 9%
- South America to Asia: 9%
- FSU to Asia: 8%
- Middle East to North America: 7%
- Middle East to Europe: 6%

- Africa to Europe: 4%

According to EIA estimates, the Strait of Hormuz (17 mb/d in 2013), leading out of the Persian Gulf, and the Strait of Malacca (15.2 mb/d in 2013), linking the Indian and Pacific Oceans, are the world's most important strategic chokepoints by volume of oil transit. More than 85% of the crude oil moved through the Strait of Hormuz went to Asian markets, particularly Japan, India, South Korea and China.

In addition, crude oil volumes have primarily increased on the long-haul routes, but have declined on the short-haul routes in 2015. Speed reductions from 14 to 12 knots have lengthened voyage times by up to 4 days. (Christopher Rex, 2016) The increase on long-haul routes of crude tankers continued in 2016, due to a combination of lower bunker fuel prices and avoidance of port charges. Since both are significant operating costs for shipping companies, many crude tankers preferred for example routes around the Cape of Good Hope of Africa instead of passing through the Suez Canal to avoid costs. Thus, they have an incentive to increase distances by changing routes as long as bunkers are cheaper[49]. Longer routes keep vessels tied up for a longer duration, which tightens tanker supply. A tight supply with no change in demand boosts tanker rates and is beneficial for the tanker industry.

Similarly, 25% of the oil product tankers' voyages in 2016 (measured in billion ton-miles) were destined to Asia. The majority of trades in the Product Tanker market are short-haul regional trades, with relatively few long-haul overseas trades. (Christopher Rex, 2016)

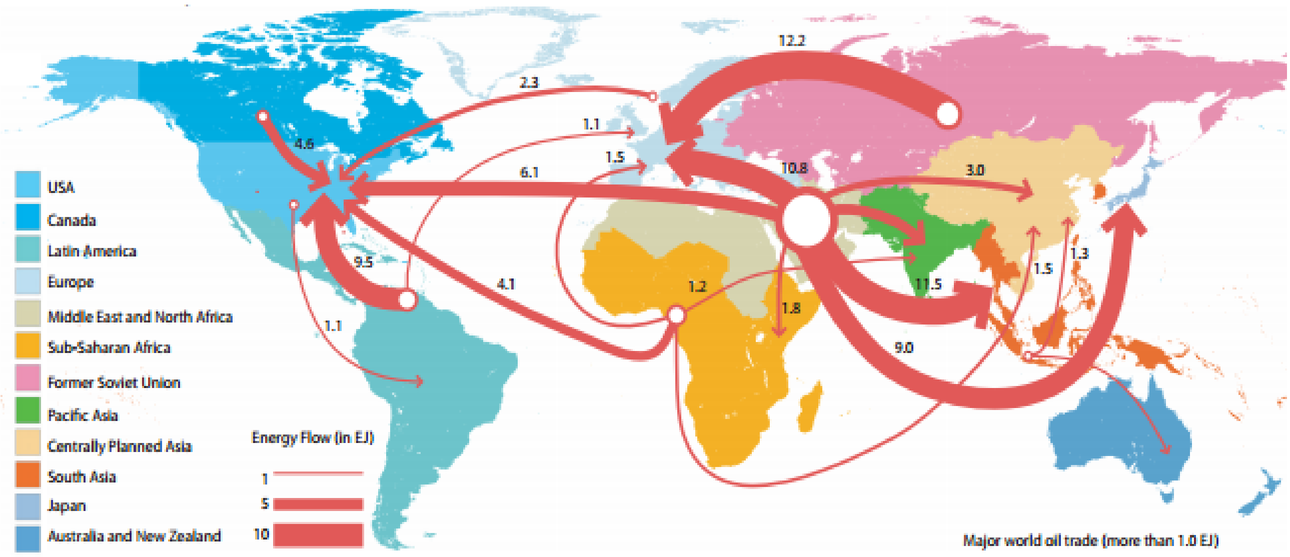
- Middle East to Asia: 8%
- Asia to Asia: 8%
- FSU to Asia: 5%
- Europe to Asia: 4%
- Asia to Europe: 4%
- North America to Europe: 4%
- FSU to North America: 4%
- Europe to North America: 3%

Figure 35 indicates that the busiest trading route back to 2005 for both crude and oil product tankers were from Middle East to Asia and Japan and from Middle East to Europe and North America. Therefore, it is easily noticed that many countries were critically dependent on oil exports from the Middle East. IEA sees that global crude trade will continue its shift eastwards to non-OECD economies in Asia by 2021, with China to be playing a leading role as it is illustrated in figure 36.

IGU (International Gas Union, 2016) report discusses that weak demand in northeast Asia has led to a decrease in demand for LNG long-haul voyages in 2015. As a result, the number of voyages trading LNG decreased to 4,057, a decline of 1.2% compared to 2014. However, as highlighted in the previous section, LNG traded volumes reached a historical high, yet total voyages decreased. This inverse relationship indicates that LNG regional trade increased particularly in the Pacific Basin, which is evidenced by looking at the voyages. The longest voyage in 2015, from Trinidad to Japan around the Cape of Good Hope, was completed only by 1 vessel. In contrast, Algeria to Spain's 4 southern terminals occurred almost 80 times and the most common voyage, from Australia to Japan, completed around 300 trips.

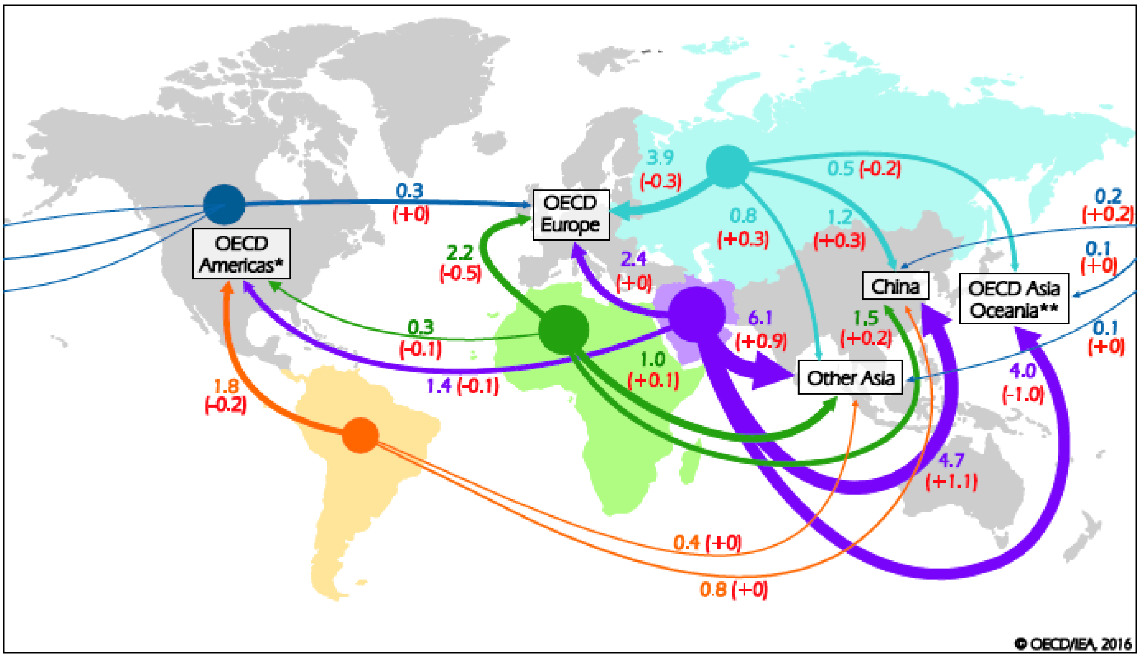
[49] Bunker prices are closely related to crude oil prices.

Figure 35: **World crude and oil products trade flows in 2005.**



Source: GEA Report, 2012.

Figure 36: **Crude oil exports in 2021 and growth in 2015-21 for key trade routes.**

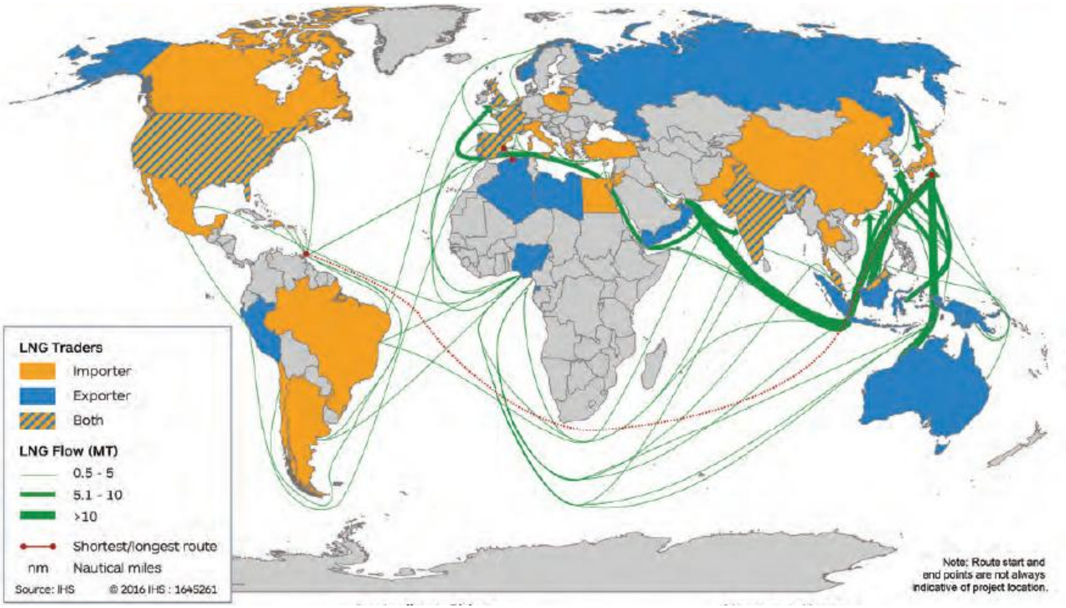


Source: IEA 2016.

Data from Danish Ship Finance (Christopher Rex, 2016) indicate a change in the trading route of LPG tankers in 2016, from North America to Asia, expanded to 16% from 5% the previous year. Major LPG tanker trades occurred with destination to Asia in 2016, therefore their shares of the total LPG tanker trade evolved as follows

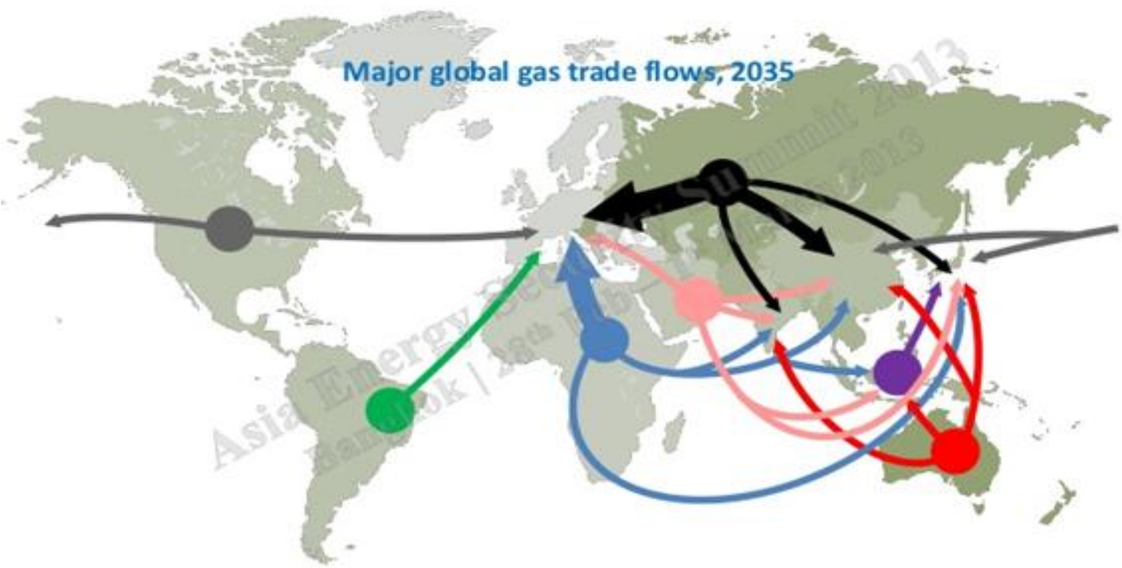
- Middle East to Asia: 43%
- North America to Asia: 16%
- North America to Europe: 4%
- Africa to Asia: 4%
- North America to South America: 2%
- Africa to Europe: 2%
- Oceania to Asia: 2%

Figure 37: **Major LNG shipping routes in 2015.**



Source: IGU, 2016.

Figure 38: **Major global gas trade flows in 2035.**



Source: Institute of Energy Economics, Japan.

As for LNG trade, in 2015, figure 37 illustrates that the most important route was, from the Persian Gulf (Qatar, Oman and Yemen) to Asia, particularly Japan and South Korea. The map clearly shows heavy concentrations of traffic through certain waterways of the world. Next inter-regional trades almost equally significant are from Malaysia to China and Japan and from Australia to Japan. Going towards a globalised gas market in 2035, IEA sees that inter-regional trade in gas will shift away from the Atlantic basin and towards the Asia-Pacific region with more diverse trade flows, helped by the rising supplies of unconventional gas (i.e. shale gas). As figure 38 shows, the emergence of new strong market players, notably Australia, United States, Canada and countries of East Africa, is of rising importance, since they will provide a competitive challenge to established suppliers such as Russia and Qatar. Europe will be seen to secure its supply from a variety of sources among them South and North America (LNG), Azerbaijan (pipeline) and Iraq (pipeline), including the traditional suppliers i.e. Norway, Russia and Algeria. (International Energy Agency, 2013)

3. Institutional framework governing maritime transport

One common characteristic that affects all segments of the tanker market, and is becoming increasingly significant, is the regulatory environment in which tankers operate. Safety at this kind of operations is of paramount importance especially in this industry, because even a minor misunderstanding of an order or a miscalculation can cause a major spill in unspoiled locations. Given the increasing environmental awareness of society at large, the regulatory environment of oil tankers has become tighter over the years. As a result, nowadays, the operations on-board an oil tanker are highly automated and conducted with no one on-board the ship or on shore seeing the cargo physically. A tanker's crew is properly trained under good management which is ensured and certified by a set of international standards. (Kumar, 2004)

The last decades, especially after World War II, it has been noticed an intensification of marine pollution. Several marine accidents are considered landmarks for legislation, notably the Titanic, the Torrey Canyon, the Herald of Free Enterprise, the Exxon Valdez, the Erica and the Prestige. These accidents provoked a public outcry and the increasing environmental awareness of society has led to the tightening of the marine and especially the tankers' regulatory environment. The goal of maritime regulators is to close the net and ensure that shipping companies operate within the same standards of safety and environmental responsibility which apply on land. Stopford (Stopford, 2009) notes that in the last 50 years the regulatory regime has played a significant part in the economics of the shipping market. During the last decade, regulators have given emphasis on matters such as environment, emissions by ships, ballast water, and ship recycling.

Accident or Vessel	Year and Area of Accident	Legislation
Titanic	1912, North Atlantic	SOLAS 1914
Torrey Canyon	1967, Pollard Rock	MARPOL 1973, STCW 1978
Exxon Valdez	1989, Alaska	OPA 1990
Scandinavian Star	1990, Norway	Safety Management System, ISM Code, STCW 1995
Estonia	1994, Baltic Sea	ISM Code, SOLAS

3.1 International

In the context of global environmental responsibility, the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 constitute landmark for further important conventions, which indirectly affect maritime transport, such as United Nations Convention on Climate Change and Convention for the Protection of Biological Diversity. It concerns the sustainable management and development of marine and coastal areas at national, regional and global level. Particularly, Agenda 21, which was adopted in Rio Conference, refers in detail to the protection of water resources, but also creates a healthy relationship between man and environment. Important developments included the adoption of the 2030 Agenda for Sustainable Development in September 2015 and the Paris Agreement under the United Nations Framework Convention on Climate Change in December 2015, in which all countries reached a landmark agreement to take measures in order to hold the increase of global average temperature below 2°C this century in an effort to combat climate change.

As regards international maritime regulation, a key player not only in the tanker industry but also in the entire maritime industry has been the International Maritime Organization (IMO), a multilateral governmental entity established under the auspices of the United Nations to promote safer shipping and cleaner seas. Additional work in the task of developing and maintaining workable regulations offers another UN agency, the International Labor Organization (ILO), which is responsible for the laws governing the people on board ships. These two organizations produce "conventions" which become law when they are enacted by each maritime state. An important international non-profit organization constitutes the International Tanker Owners Pollution Federation Limited (ITOPF) established in 1968 in the wake of the "Torrey Canyon" oil spill to manage the oil spill compensation scheme known as TOVALOP. Its main activities today is to provide a wide range of technical services in response to spills, claims analysis and damage assessment, contingency planning, training and information. Another important International Association of Independent Tanker Owners is INTERTANKO. INTERTANKO has been the voice of independent tanker owners since 1970, ensuring that the liquid energy is shipped safely, responsibly and competitively.

The ***1973/1978 MARPOL*** is the International Convention for the Prevention of Pollution from Ships, one of the most important international marine environmental conventions, developed by the IMO. MARPOL adopted in 1973 and revised in 1978. Its objective is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances from operational or accidental causes incurred by ships. As of 14 March 2017, MARPOL is signed by 155 states which constitute approximately 99% of the gross tonnage of the world's merchant fleet. The operational and construction regulations introduced by MARPOL, which entered into force in 1983, have helped to ensure that the majority of oil tankers are safely built and operated and are constructed to reduce the amount of oil spilled by oil sea transportation. The requirement for new oil tankers to be fitted with segregated ballast tanks and the requirement for oil tankers delivered from 1996 onwards to be fitted with a double hull, have contributed greatly to a noticeable decrease in the oil pollution of the world's seas.

The International Convention for the Safety of Life at Sea (***SOLAS 1974***), which revised and expanded in 1995, is an international maritime treaty which purpose is to ensure that ships flagged by its signatory states comply with minimum safety standards in construction, equipment and operation of ships. As of March 2017, SOLAS is signed by 163 countries, which flag about 99.14% of the world's merchant ships in terms of tonnage. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (***STCW 1978***), sets qualification standards for masters, officers and watch personnel on seagoing merchant ships. It has established the basic requirements on training, certification and watchkeeping for seafarers on an international level. As of 14 March 2017, STCW is adopted by 162 state parties, representing 99.18% of the world's fleet tonnage.

The most radical regulatory impact on tanker industry came from a unilateral regulation enacted by the United States in a response to the grounding of the oil tanker "Exxon Valdez" off Alaskan waters on 24 March 1989 which caused a crude oil spill of 10.8 million gallons. The ***Oil Pollution Act of 1990*** (OPA 90), passed by the U.S. Congress, works to prevent oil spills from vessels and facilities by enforcing the removal and clean up and assigning liability on those responsible for spills, and compensate those who suffer resulting economic damage. It also mandated the replacement of single-hull tankers for new double hull tankers and established a phase-out period for the existing single-hull tankers. Therefore, many tanker owners responded to this legislation by staying temporarily away from the U.S. market, because of the large investment cost requirements in order to reach the U.S. national waters. (Kumar, 2004)

Investigation on the past casualties of incidents has shown that some flag states often were negligent in enforcing law requirements. As a consequence, many countries introduced a procedure of port state control inspections with purpose to ensure that vessels visiting their ports comply with international standards. Today, this procedure of the local port authorities is very common in most trading areas, and result in rogue ships being arrest and their names being publicized through the media. (Kumar, 2004)

With regards to carriage of chemicals in bulk, it is covered by regulations in SOLAS Chapter VII - Carriage of dangerous goods and MARPOL Annex II - Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Important codes arising from the aforementioned conventions which are worth to be noted and codes in relation to the carriage of the liquid energy commodities analyzed in previous sections are as follows:

- ***International Safety Management (ISM) Code,*** entered into force on 1 July 1998 as part of SOLAS, is a complete guideline for ship owners and operators providing an international standard for the safe management and operation of ships for the prevention of maritime pollution. The Code establishes safety-management objectives and requires a safety management system (SMS) to be established by the Company, which is required to implement a policy for achieving the code's objectives by recording the procedures into a Safety Management Manual, a copy of which should be kept on board.
- ***International Ship and Port Facilities Security Code (ISPS Code)***, enforced on 1 July 2004, is part of SOLAS and is meant to safeguard maritime ports and ships from threats. It prescribes responsibilities to governments, shipping companies, shipboard personnel, and port/facility personnel to detect security threats and take preventative measures against security incidents affecting ships or port facilities used in international trade. IMO states that "The ISPS Code is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities in the wake of the 9/11 attacks in the United States".
- ***International Maritime Dangerous Goods Code (IMDG Code)***, was adopted in 1965 as part of SOLAS, is an international guideline to the safe transportation or shipment of dangerous goods or hazardous materials by vessel. The Code contains classification of the dangerous goods and sets the requirements and procedures concerning transport operations of these consignments. The Code also contains advice on terminology, packaging, labeling, placarding, markings, stowage, segregation, handling, and emergency response. There have been constant amendments to the code, since marine transportation undergoes a lot of developments. The edition in force is the 2014 Edition which became mandatory on 1 January 2016; Incorporating Amendment 37-12. The amendments are proposed every two years and the adoption of the amendments takes place after two years of the proposal by the concerned authorities.
- ***International Bulk Chemical Code (IBC Code)***[50] adopted in October 2004, provides guidelines to chemical tankers on operational, construction, and safety aspect. The Code

[50] Chemical tankers constructed before 1 July 1986 should comply with the requirements of the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code), which is the predecessor of the IBC Code. The BCH Code remains as a recommendation under the 1974 SOLAS Convention.

sets out the international standards for the safe carriage, in bulk by sea, of dangerous chemicals and noxious liquid substances. The Code defines a list of chemicals and their hazard rating, prescribes the design and a construction standard of ships involved in the transport of bulk liquid chemicals and identifies the equipment to be carried to minimize the risks to the ship, its crew and to the environment.

- ***International Gas Carrier Code (IGC Code)*** provides guidelines to gas tankers on operational, construction and safety aspects. The Code has been mandatory under SOLAS chapter VII since 1 July 1986. It defines the substances, it prescribes the design and construction standards of ships involved in such carriage and the equipment they should carry.
- ***International Code on the Enhanced Program of Inspections during surveys of bulk carriers and oil tankers (2011 ESP Code)***, entered into force on 1 January 2014 and provides requirements for an enhanced program of inspections during surveys of single-hull and of double-hull bulk carriers and single-hull and double-hull oil tankers. It also provides special requirements for renewal, annual and intermediate surveys, preparation for surveys, and documentation on board, procedures for thickness measurements, reporting and evaluation of surveys.
- ***International Code for Ships Operating in Polar Waters (the Polar Code)*** adopted by IMO in 2014 and enforced by January 2017, has been a proposed binding international framework to protect the two Polar Regions, Arctic and Antarctic, from maritime risks. The Code passed not as a new body of legislation, but rather as supplement to an existing body of international law. Since the United States Geological Survey in 2008 announced potentially large quantities of technically recoverable oil in the Arctic region, representing 13% of the undiscovered oil in the world, international focus on the Arctic has intensified by a variety of interest groups. The Code (added in SOLAS Chapter XIV and MARPOL Annex I, II, IV and V), acknowledges that polar water operation may impose additional demands on ships, their systems and operation beyond SOLAS and MARPOL.

3.1.1 Regulatory Developments

The two last decades, maritime regulatory environment has undergone significant amendments along with developments in maritime industry.

As regards developments in ***MARPOL Convention***, Annex IV entered into force on 27 September 2003 which contains requirements to control pollution of the sea by sewage from ships and Annex VI entered into force on 19 May 2005 which contains regulations for the prevention of air pollution from Ships. Both Annexes are voluntary applicable by state parties, Annex IV amended twice, while Annex VI amended four times after its enforcement. Particularly, Annex VI sets limits on sulphur oxide (SOx) and nitrogen oxide (NOx) emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. The recent amendments contain provisions allowing for special Emission Control Areas, called ECAs, (including the Baltic Sea, North Sea and seas around North America, U.S. and Caribbean), to be established with more stringent control on sulphur and nitrogen oxide emissions. The limits applicable in ECAs for SOx and particulate matter were reduced to 0.10%, from 1 January 2015 and progressive reductions in NOx emissions from marine diesel engines installed on ships are also included. They include a global cap of 3.50% m/m on the sulphur content of fuel oil used on board ships. They also added a new chapter to make mandatory the Energy Efficiency Design Index (EEDI), for new ships, and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. Other amendments added new definitions and requirements for survey and certification, including the format for the International Energy Efficiency Certificate.

As far as tanker amendments is concerned, after the U.S. initiative (OPA 90), IMO enacted new tanker design rules by amending MARPOL in 1992 to make mandatory for tankers of more than 5,000 dwt ordered after 6 July 1993 to be fitted with double hulls, providing the ship owners the option of building tanker with double hulls or an alternative design approved by IMO. Despite all new regulations, accidents did continue to happen, as illustrated in the case of "Erica" spillage which caused IMO, under pressure from European Union, to amend the Annex I of MARPOL Convention in April 2001 (revised also in 2003) and speed up the phasing out of single-hull tankers. The amendment also included the authorization of the member states to ban the entry of single-hull tankers that are more than 25 years old (Kumar, 2004). The 2003 amendments entered into force on 5 April 2005, which contained a revised regulation of Annex I. The final phasing-out date for Category 1 tankers (pre-MARPOL tankers) is brought forward to 2005, from 2007. The final phasing-out date for category 2 and 3 tankers (MARPOL tankers and smaller tankers) is brought forward to 2010, from 2015. It also banned the carriage of heavy grade oil in single-hull tankers of 5,000 dwt and above.

More recently, IMO recognizing the need to gather all the applicable requirements for recognized organizations acting on its behalf, in a single IMO mandatory instrument. Therefore, IMO adopted ***the Code for Recognized Organizations*** (RO Code) which entered into force on 1 January 2015 under MARPOL annex I and II and SOLAS. The Code provides a consolidated instrument containing criteria against which Recognized Organizations are assessed and authorized/recognized, and gives guidance for subsequent monitoring of Recognized Organizations by Administrations.

Following the ***OPRC Convention***, that is the establishment of measures for dealing with *oil pollution incidents*, the Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS Protocol) extends the scope of the OPRC Convention by applying to *pollution incidents of hazardous and noxious substances*. The Protocol adopted on 15 March 2000 and enforced on 14 June 2007. Both Convention and the Protocol require parties to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard pollution emergency plan to deal specifically with incidents involving oil or hazardous and noxious substances. The OPRC-HNS Protocol ensures that ships carrying hazardous and noxious substances are covered by preparedness and response regimes similar to those already in existence for oil incidents.

As far as ***SOLAS Convention*** amendments are concerned, it has been amended many times to keep it up to date by IMO. The most recent worth mentioning amendments are the following:

- A revised chapter V (Safety of Navigation) enforced on 1 July 2002, which brings in a new mandatory requirement for voyage data recorders (VDRs) to assist in accident investigations. It also requires automatic identification systems (AIS), capable of providing information about the ship to other ships and to coastal authorities automatically.
- A revised chapter II-2 (Construction, Fire protection, fire detection and fire extinction) as well as a new International Code for Fire Safety Systems (FSS Code) were enforced on 1 July 2002.
- The amendments to chapter VII (Carriage of Dangerous Goods) made the IMDG Code mandatory on 1 January 2004.

- A new chapter created for ISPS Code containing the mandatory measures to enhance maritime security, entered into force on 1 July 2004. (explained in more detail in the previous subsection)
- A new text for chapter XII (Additional safety measures for bulk carriers), entered into force on 1 July 2006, which includes specific structural requirements for bulk carriers over 150 metres in length.
- New regulation on LRIT is included in chapter V on Safety of Navigation which enforced on 1 January 2008. LRIT introduced as a mandatory requirement for the following ships on international voyages: passenger ships, cargo ships, of 300 gross tonnage and upwards; and mobile offshore drilling units.
- Amendments to chapter VI made mandatory the International Maritime Solid Bulk Cargoes Code (IMSBC Code), on 1 January 2011.
- Amendments to Chapter V (Safety of Navigation) made mandatory the carriage of Electronic Chart Display and Information Systems (ECDIS) and Bridge Navigational Watch Alarm Systems (BNWAS) on 1 January 2011.
- On 1 January 2012 new regulation about ship construction standards introduced to chapter II, named "Goal-based standards", which apply to oil tankers and bulk carriers of 150m in length and above. It is new ship structural requirements so as to be safe and environmentally friendly throughout their lifecycle. New regulation also adopted on the same chapter for the protection against corrosion of cargo oil tanks of crude oil tankers.
- On 1 January 2016 the new Chapter XIII was approved to make the use of the IMO Instruments Implementation Code (III Code) mandatory. The aim is to enforce the Governments who accept an IMO Convention to make it part of its national law.
- Amendments related to the mandatory verification of the gross mass of containers, entered into force on 1 July 2016, which will contribute to improving the stability and safety of ships and avoiding maritime accidents.

Other important Conventions that have been recently adopted relating to prevention of marine pollution are the following:

- *International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS)* adopted in 2001 and signed by 75 states representing 93.67% of the world gross tonnage. State parties prohibit the use of harmful organotins in anti-fouling paints used on ships flying their flag and establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.
- *International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM)* adopted in 2004 and signed by 54 states representing 53.41% of the world gross tonnage. It aims to prevent the spread of harmful aquatic organisms from one region to another, as they present a major threat to the marine ecosystems. Because shipping has been identified as a major pathway for introducing species to new environments, the convention's role is critical for the establishment of standards and procedures for the management and control of ships' ballast water and sediments.
- *The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships* adopted in 2009 and has yet to be enforced[51]; signed by 5 states representing 19.99% of the world gross tonnage. Its aim is to ensure that ships are being recycled after

[51] It will enter into force 24 months after ratification by 15 States, representing 40 per cent of world merchant shipping by gross tonnage.

reaching the end of their operational lives, do not posing any unnecessary risk to human health and safety or to the environment.

3.2 European[52]

The institutions of European Union issued regulations, over the years, enforced to Member States concerning the protection of the marine ecosystem from operational or accidental pollution arising from ships, by keeping in mind the provisions of the United Nations Convention on the Law of the Sea, particularly Part XII "Protection and Preservation of the Marine Environment", and the provisions of MARPOL 73/78.

As far as *EU primary legislation* is concerned, one of the first sectors of Common Policy included on the founding Treaties of Rome (1957) was Transportation. In fact, Member States highlighted the importance of a common policy for transport by devoting a separate title for this matter in the Treaty, but there was not any specific reference to maritime transport in the context of the Common Transport Policy. (Σωτήρης Θεοδωρόπουλος, 2006)

Regarding *secondary legislation*, the period 1974-1986 is characterized by limited initiatives from EU in relation to adoption of maritime policies. Amoco Cadiz accident in 1978 essentially caused the Community to take action with a special resolution on 26 June 1978. Thus, an action program of the European Communities was set up on the control and reduction of pollution caused by hydrocarbons discharged at sea. In addition, Council adopted two important directives concerning minimum standards for certain tankers using Community ports, as well as pilotage of vessels by deep-sea pilots in the North Sea and English Channel. The European Parliament brought proceedings against the Council to the Court of Justice of the European Union for violation of the Treaty of Rome, because little progress was made towards the common transport policy. (Σωτήρης Θεοδωρόπουλος, 2006)

The period 1986-1990, EU was searching for policies about competitiveness of flags of the member states and started to make attempts to create a framework for a Community Shipping Policy. The adoption of the 'four directives' in December of 1986 provided the means for coordination of policies between the member states against unfair pricing practices of non-EU countries (dumping) and against the noticed trend of the European ship owners of "flagging out[53]". The four initiatives aim to ensure competition, free access to the market, freedom to provide services in maritime transport, as well as protection of market share of the European ship owners and maritime contribution in the European economy. In 1989, measures proposed by the European Commission to improve the operating conditions of Community Shipping, since the first package of measures did not achieve its goals. The Community fleet continued to shrink at that time. The main point of the measures was to create a Community ship register (European Registry of Shipping) offering economic benefits. However, due to criticism from several states, mainly Denmark and Great Britain, and disputes of its effectiveness, European Commission was forced to withdraw its proposal in 1996. (Σωτήρης Θεοδωρόπουλος, 2006)

The period 1990-1996 is characterized by broadening of topics related to maritime sector, development of the European policies for shipping and redefinition of the European maritime transport strategy in 1996. At the begging of 1990s, European Commission decided to promote

[52] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l24064&from=EL, accessed on 12.04.2017

[53] Flagging out refers to the practice of switching the vessel's registration to a country other than that of the ship's owners, to operate it under a "flag of convenience". Flags of convenience often are preferred to reduce operating costs or avoid the regulations of the owner's country.

a new global and horizontal approach concerning the whole maritime transport system[54]. Particularly, Commission expressed the view that maritime challenges and issues must be recognised as parts of an overall maritime dimension and they have to be tackled on the basis is of all maritime industries and all related research institutions and no longer on *ad hoc* basis. Emphasis was given in environmental dimension which highlighted the need for sustainable mobility[55]. In 1992, Regulation 3577/92/EEC eliminated restrictions on the freedom to provide maritime transport services within the EU (known as maritime cabotage). By 1996, European Commission issued two texts, *"Towards a new maritime strategy"*[56] and *"Shaping Europe's maritime future"*[57] in which the position of Community shipping initiatives enhanced in three main key areas:

- safety and fair competition in the implementation of international regulations;
- maintaining open markets;
- a policy for competitiveness of maritime industries[58].

The context of those strategies was approved by both European Parliament and Council and it provides the legal basis of today for the further development of European maritime transport policies.

In the context of modernization of maritime service infrastructure, a Green Paper was published on 10 December 1997 about seaports and maritime infrastructure[59] which constitutes essential starting point towards a policy making of European port industry.

In 1992, the first White Paper and Maastricht Treaty were trying to overcome the difficulties on the future development of a 'Common Transport Policy' by opening the market of transport sector and developing the trans-European networks. The White Paper also introduced the framework for "sustainable mobility". In 2001, another White Paper[60] proposed 60 measures for balancing the modes of transport inside the Community, because of the noticed uneven development between the different means of transport. Given the congestion of the road network, main goal of the 'Common Transport Policy' until 2010 was *to promote the inland waterway and short sea shipping*, but also to revitalize the rail transport and control the growth in air transport. Maritime transport was at the heart of the Common Transport Policy because it represented back then the 70% (in 2015 the number is 51%) of the total trade in goods between EU and third countries. (Σωτήρης Θεοδωρόπουλος, 2006) However, the latest White Paper[61] of 2011 related to EU transport system did not referred so much on maritime transport; introduced mostly environmental goals and a roadmap on reducing Europe's dependence on imported oil. Particularly, it set the goals for every means of transport so as to reach the goal of cutting carbon emissions in transport by 60% by 2050. Concerning urban transportation, it proposes the gradual elimination of conventionally-fuelled cars in cities. Regarding medium distance intercity transportation, it proposes a 50% shift of passenger and freight journeys from road to rail and waterborne transport.

[54] Com (91) 335
[55] Com (92) 46, "The Impact of Transport on the Environment"
[56] Com (96) 81
[57] Com (96) 84
[58] Maritime industries consist of a wide range of goods and services; shipbuilding, port industries, equipment, fishery, energy etc.
[59] Com (97) 678
[60] Com(2001) 370, "European transport policy for 2010: time to decide"
[61] Com(2011) 144, "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system"

Commission had already stated its view that the measures proposed in 2001 were not comprehensive enough to achieve the objectives set. In June 2006, the Commission published a Green Paper on the different aspects of a future Community maritime policy. It considers what new tools and modes of maritime governance should be developed. For the promotion of Inland Waterway Transport, Commission developed an Integrated European Action Program in 2006 called "Naiades"[62] which later on updated and renewed by "Naiades II"[63] (2013). In 2009, Commission presented a Communication which set *the strategic goals and recommendations for the EU's maritime transport policy until 2018*[64] whose main point was to maintain stable global competitive conditions for shipping and other maritime industries in the face of economic slowdown and strengthen the competitiveness of European maritime clusters. Community actions aim to promote better use of information and communication technologies (ICT); enforcement of international requirements under STCW and maritime safety; reduce greenhouse gas emissions (GHG) from international shipping; strengthen legislation regarding port reception facilities for ship-generated waste; exploit full potential of short-sea shipping; become the world leader in maritime research and innovation.

As far as ***maritime safety*** is concerned, 'three legislative packages' adopted mainly in the aftermath of the Erika (1999) and Prestige (2002) disasters. They transposed international rules into EU law and brought about greatly improved safety standards in sea transport.

Erika I package standardized the legal provisions on ship inspection and survey organizations (classification societies) by introducing a system of liability in the event of proven negligence on their part. The rules made also port State control by Member States mandatory for certain potentially hazardous vessels by introducing a 'blacklist' of ships which can be refused access to EU ports. The regulations also set a fixed timetable for the replacement of single-hull oil tankers by safer double-hull vessels.

Erika II package established a Community vessel traffic monitoring and information system (Safe Sea Net) and a European Maritime Safety Agency (EMSA). Automatic identification systems (AIS) and voyage data recorders (VDRs) become mandatory equipment of ships. EMSA's core tasks include the development of EU legal acts in line with international legislation, effective implementation of the binding legal acts and support for pollution response actions.

The *3rd Maritime Safety Package* in December 2008, comprising two regulations and five directives, aimed to improve port State controls with instructions for more frequent and more effective inspections; to establish common rules and standards for ship inspection and survey organizations, aiming at an independent quality-monitoring system; to enable the effective monitoring of compliance on the part of ships flying a Member State flag with international provisions; to improve the framework legal conditions concerning places of refuge for ships in distress and to further develop Safe Sea Net; to establish fundamental principles governing the investigation of accidents, with standard principles for investigations at sea of marine casualties and incidents that involve vessels flying the flag of an EU Member State and occur in the territorial sea or internal waters of a Member State; to define the liability of carriers of passengers by sea in the event of accidents; to lay down rules for or port State control and the obligations on ship owners as regards their insurance for maritime claims.

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[62] Com (2006) 6
[63] Com (2013) 623
[64] Com (2009) 8

In recent years, numerous measures comprising three directives and one regulation have been adopted on ***protecting the marine environment***. They include compulsory measures to dispose of oil, oily mixtures, ship-generated waste and cargo residues on port reception facilities; prohibition of organotin compounds on ships in line with AFS Convention; regarding ship-source pollution and introduction of penalties for infringements; regarding cargo vessels sailing in the English Channel, the North Sea and the Baltic Sea have no longer been able to use fuel containing more than 0.1% sulphur in accordance with Annex VI to the MARPOL Convention. Lately, the Marine Strategy Framework Directive (Directive 2008/56/EC) is the first EU legislative instrument related to the protection of marine biodiversity. Its objective is to reach Good Environmental Status (GES) of the marine waters by 2020, to continue its protection and preservation, and to prevent subsequent deterioration.

3.3 National

The development of the Greek merchant shipping is based on the existence of a stable institutional legislative framework. 'Ministry of Shipping and Island Policy' is the regulatory institution that is responsible for the development of the ***Greek Registry*** whose main legislation is the following:

- The Code of Public Maritime Law (ΚΔΝΔ), Ν.Δ. 187/73
- The Code of Private Maritime Law (ΚΙΝΔ), Ν. 3816/58
- The Registry Approval Acts (Article 13, Ν.Δ. 2687/53).

The first attempt of the Greek government to form a maritime policy and draw foreign capital to the country comes back in 1953 with the enforcement of a legislative decree 2687/1953, in particular article 13, regarding investment and protection of foreign funds. These special provisions enabled individuals or legal entities to register ships of more than 1500 gross tonnage in the Greek Registry provided that share capital of the shipping company that owns the particular ship is by more than 50% in Greek interests. Following the conviction of Greece by the Court of Justice of the European Communities, the existing framework amended by the legislative decree 11/2000 (Φ.Ε.Κ. Α'27.01.2000) by which ship owners of EU countries may register their ship at Greek Registry provided that the management of the ship is executed from Greece. (Παπαγιαννούλης, n.d.)

The legislative decree 2687/53 has been and continues to be fundamental for Greek commercial shipping legislation, which secured the Greek-owned vessels repatriation to the Greek Registry during the 1950s. Today it constitutes the main motivation for the registration of ships in the Greek flag.

Many small family-run shipping companies in Greece are established under law 959/79 whose structure is similar to the 'public limited company' but its management having larger flexibility. The purpose of these companies is limited to management and commercial exploitation of merchant ships flying only Greek flag. (Παπαγιαννούλης, n.d.)

As regards shipping ***tax legislation*** in Greece, an important law is 89/67 which allows foreign commercial and industrial companies to relocate in Greece without taxing their revenues. The law 89/67 expanded later to 378/68 for shipping companies, while the 465/68 introduced new taxation measures which were based on age and size of their fleet and not according to their revenues. As a result, there were a large number of licenses given to foreign shipping companies for opening an office in Greece without being active and without making notable inflow of foreign exchange, while they were enjoying all the benefits of aforementioned laws. Hence a new law adopted, law 25/75, containing the terms of management of ships being in Greek interests owned by shipping companies which establish a branch office in Greece. The article 25 of 25/75 which described the requirements for the establishment of a branch office in Greece was replaced by the article 28 of law 814/78 which tightened up the rules. The laws 25/75 and 814/78 are still in force and represent the today's tax regime regarding the establishment of foreign shipping companies in Greece. (Παπαγιαννούλης, n.d.) Recently, by 2001, Greek government with law 2932/2001 (ΦΕΚ Α' 145/2001) lifted restrictions in maritime cabotage by applying the principle of freedom to provide services to maritime transport in line with European (Regulation 3577/92).

As far as ***maritime safety*** is concerned, most of the international and EU regulations are harmonized into Greek law, of which the most important laws concern port state control and vessel traffic monitoring further to EU instructions as follows:

- Legislative Decree 93/1974[65] (ΦΕΚ Α' 293/1974), ratification of Convention on the International Regulations for Preventing Collisions at Sea, 1972;
- Presidential Decree 49/2005 (ΦΕΚ Α'66/2005), regards embodiment of Directive 2002/59/EC for establishing a Community vessel traffic monitoring and information system;
- Presidential Decree 103/2011[66] (ΦΕΚ Α'236/2011), regarding common rules and standards for organizations of ship inspection and control and for the relevant activities of maritime authorities in accordance with EU Directive 2009/15/EC of April 23, 2009;
- Presidential Decree 16/2011[67] (ΦΕΚ Α' 36/2011), regarding port state control according to EU Directive 2009/16/EC of April 23, 2009;
- Law 4033/2011[68] (ΦΕΚ Α'264/2011), for establishing the fundamental principles governing the investigation of accidents in the maritime transport sector according to EU Directive 2009/18/EC of April 23, 2009;
- Presidential Decree 6/2012, (ΦΕΚ Α' 7/2012), on the insurance of ship owners for maritime claims of April 23, 2009;

Greek Ministry of Shipping has a separate Division both as a 'flag state'[69] and 'coastal state'[70] for Security Control of Ship and Port Facility to unsure that is keeping national law in line with the updates in the provision of SOLAS and ISPS Code.

The Greek flag is part of the White List of IMO and Paris Memorandum of Understanding, highlighting the fact that Greek flag is one of the high quality flags internationally.

With regard to ***maritime environment***[71], in 1995, Greece ratified the United Nations Convention on the Law of the Sea (UNCLOS), one of the world's most important conventions, which define the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. Greek Ministry of Shipping has been embodied gradually both international and EU

[65] https://www.yen.gr/web/guest/dan-asfnafs-nomoi-pd, accessed on 18.04.2017
[66] https://www.yen.gr/web/guest/dan-nomothesias-nomoi-pd, accessed on 18.04.2017
[67] https://www.yen.gr/web/guest/dan-paris-mou-nomoi-pd, accessed on 18.04.2017
[68] https://www.yen.gr/web/guest/dep-archeio-nomothesia, accessed on 22.04.2017
[69] As a flag state, Greece enforces state's laws on ships flying the Greek flag.
[70] As a coastal state, Greece is responsible to enforce laws, which comply with international maritime conventions, on ships in Greek territorial waters. This is known as 'port state control', which is the inspection of foreign ships in national ports to verify that its condition, crew, equipment and operations comply with the requirements of international regulations.
[71] https://www.yen.gr/web/guest/dpthp-nomoi-pd, accessed on 17.04.2017

legislation with laws, presidential decrees, Minister Decisions or other regulatory provisions regarding protection of maritime environment into Greek national law since 1976:

- Law 314/1976 (ΦΕΚ 106 Α 05-05-76), ratification of International Convention on Civil Liability for Oil Pollution Damage (1969);
- Law 743/1977 (ΦΕΚ Α'319), regarding protection of maritime environment, as codified with Presidential Decree 58/1998 (ΦΕΚ Α' 58/1998);
- Law 1147/1981 (ΦΕΚ Α'110/1981), ratification of Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, as superseded by 1996 Protocol;
- Law 1269/1982 (ΦΕΚ Α'89/1982), ratification of International Convention MARPOL 73/78;
- Law 1638/1986 (ΦΕΚ Α'108/1986), ratification of International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971), as superseded by 1992 Protocol (Law 3482/06, ΦΕΚ Α'163/2003);
- Law 2252/1994 (ΦΕΚ Α' 192/1994) ratification of International Convention on Oil Pollution Preparedness, Response and Co-operation (1990);
- Presidential Decree 32/1997 (ΦΕΚ Α'35/1997), regarding common rules and standards for organizations of ship inspection and control and for the relevant activities of maritime authorities in accordance with EU Directive 94/57/EC of November 22, 1994;
- Presidential Decree 88/1997 (ΦΕΚ Α'90/1997), regarding enforcement of international standards for ships using EU ports or sailing in waters under the jurisdiction of Greece and related to ship safety, pollution prevention and living and working conditions on board ships (port State control) in accordance with EU Directive 95/21/EC of June 19, 1995;
- Law 3394/2005 (ΦΕΚ Α' 243/2005) ratification of International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001);
- Law 3983/2011 (ΦΕΚ Α' 144/2011), regarding national strategy for the protection and management of the marine environment in accordance with EU Directive 2008/56/EC.

Greek Ministry of Shipping has accepted and adopted most of the recently revised Annexes of MARPOL Convention regarding Polar Code and prevention of air pollution from shipping industry.

4. Determinants of the international market of liquid energy goods and shipping market of liquid energy goods

Previous sections made clear that because oil and gas market are global industries, they are not only affected from global economy and main actors' markets but also from global incidents, demographic factors, technological developments, global policy and geopolitical tensions and trends evolving in the market. Below some observations and comments are unfolded of the factors that affect international oil and liquid gas commodity market as well as shipping market of liquid energy commodities.

According to the IMF report of October 2016, short-term risks to *global financial stability* have diminished by April 2016, but medium-term risks are still a threat. Advanced economies are facing weak profitability, low growth and low interest rates, while their regulatory environment evolves. Favourable external environment in emerging market economies and developing economies presents business opportunities, while the political environment is uncertain. Further to April 2017 IMF report, economic activity has gained momentum and longer-term interest rates have risen, but political and policy uncertainty continues to be a threat to financial stability. Policy decisions at this point are crucial, as a shift toward protectionism in advanced economies could reduce global growth and trade, impede capital flows, and dampen market sentiment. This described situation in global economy influences investment decisions of all companies around the globe, including large oil and gas corporations and shipping companies. Consequently, investment decisions influence oil and gas production and supply which affect directly the derived demand for maritime transport services. Furthermore, economic growth driven by industrial output also affects a country's demand for energy and therefore demand for maritime transport services.

Oil prices fluctuations in the short-term could induce responses from supply and demand or policy, or a combination of three, which would prevent prices from rising further or falling below a certain point. On the demand side, high oil prices would have an adverse impact on oil demand and vice versa, as income would be relatively smaller, consumers would demand less oil. Furthermore, high oil prices would eventually slow economic growth and induce recessionary pressures, with a detrimental effect on global oil demand. On the supply side, high oil prices provide incentives to investment in the oil sector resulting in a supply response with a multi-year lag. In addition, high oil prices encourage substitution of oil and development of alternative energy sources, because oil price is increased relative to other energy sources.

Demographic trends and *structural shifts* happening in most developed as well as in some developing countries affect energy demand and as a result oil and gas markets. For example, China is warned that will face a demographic crisis over the next 15 years. The aging of the population will accelerate, while the working-age population will shrink, damaging economic growth. At the same time, China's rebalancing economy from energy-intensive industrial sector to expansion of the services sector is leading gradually to a slower growth in country's energy demand and reduction in energy intensity.

Global policies are crucial such as the Paris Agreement on climate change which gives impetus to an energy transition towards a lower-carbon and more efficient energy system, resulting again to a slower growth in global energy demand for fossil fuels. The pledges of countries will expand the use of cleaner energy sources worldwide, mostly renewable energy. In addition, *technological advances* for instance in car vehicle transportation are helping to the deployment of renewable energy, energy efficiency improvements and reduction in carbon emissions.

Policy shift implications emerge from the agreement of OPEC members and several other major producers, such as Russia, to limit supply, which may affect oil prices and, in turn, oil and gas industry.

Geopolitical, other unpredictable incidents and because oil and gas resources are concentrated in the Middle East and other politically unstable areas, global concerns for energy security of supply have been grown among importing countries. Strong example with political implications constitutes the Russian-Ukrainian gas crisis of 2006 and 2009, where dept and prices disputes between the countries resulted in cut offs in gas supply of many European countries for 3 days caused an outcry all over Europe.

4.1 Factors affecting global oil and gas supply

As far as oil and gas supply is concerned, changing developments in domestic market of the main energy actors are likely to affect the global oil and gas industry. In terms of supply, the key energy market players are U.S.A, Saudi Arabia, Russia, Qatar, OPEC and National Oil Companies.

As regards to market structure, the fact that most proved reserves are controlled by a few (suppliers) producing countries, distributed to many (buyers) consuming countries and there is state intervention in the oil and gas supply chain in most of these countries, shapes producer-customer relations. Because of state intervention, producers' investment decisions do not always come from economic 'market' factors but they also originate from political factors. In addition, oil creates large economic rents, which producing and consuming countries are fighting for, far beyond the normal competition among market players. Cartels exist in the market, such as OPEC which they are also trying to affect the market by limiting their output. (Christopher Allsopp, 2013)

Technological breakthroughs may help in the development of alternative fuels of crude oil. For now, oil will continue to be required in the transport sector, being its main demand driver, where substitution is extremely difficult. Though technological developments are difficult to predict, economic incentives are in place.

In **USA**, noteworthy technological developments, which proved to be a game changer of the energy landscape in US market, have been the shale gas and shale oil revolution. There was expected that US would become a major importer of LNG, competing with Europe and Asia. Instead, LNG imports fell and US became a major producer and consumer of natural gas with great benefits to US economy. In fact, US gas production increased by 42% from 2005 to 2013. (Roberto F. Aguilera, 2013) In the case of oil the number is even larger; oil production has risen spectacularly by 64% from 2008 to 2013. Thus, a dominant proportion of the new unconventional oil and gas quantities filled the gap of the conventional declining domestic production therefore the much discussed US growth for oil and LNG imports eliminated. The shale sector, by taking into account direct and indirect employment yielded, contributed by 1.5% to US GDP according to IHS estimates (Roberto F. Aguilera, 2013).

This new factor appeared in US has changed the image of global oil and gas supply, demand and trade. The collapse of US LNG imports has had a dampening impact on prices in Europe and Asia which were temporarily mitigated by the increased Japanese demand after Fukushima disaster. (Roberto F. Aguilera, 2013) Therefore, Russian national gas company, Gasprom, has been forced to make painful adjustments due to the much lower spot prices in the European market.

Gasprom's pricing power, revenues and production growth prospects were hit. (Roberto F. Aguilera, 2013) However, oil market being truly global, the impact of changes occurred in USA, becomes diluted. The main change related to the oil market that shale oil brought is a decline in US import needs. This decline, however, has given a boost to oil tanker trade. Average travelling distance increased, as Venezuelan and Angolan oil delivered normally to the US East Coast had to swap for more extended distances in Asian destinations (Roberto F. Aguilera, 2013). Many researchers (Roberto F. Aguilera, 2013) support that the revolution is projected to extend to around the world, inducing substantial economic and geopolitical impacts for energy producing and consuming nations. Some analysts also see US as a potential net exporter of gas to the rest of the world. US Policies are also leading to this direction; the lifting of US crude oil export ban in December 2015 allows new crude trade flows to develop.

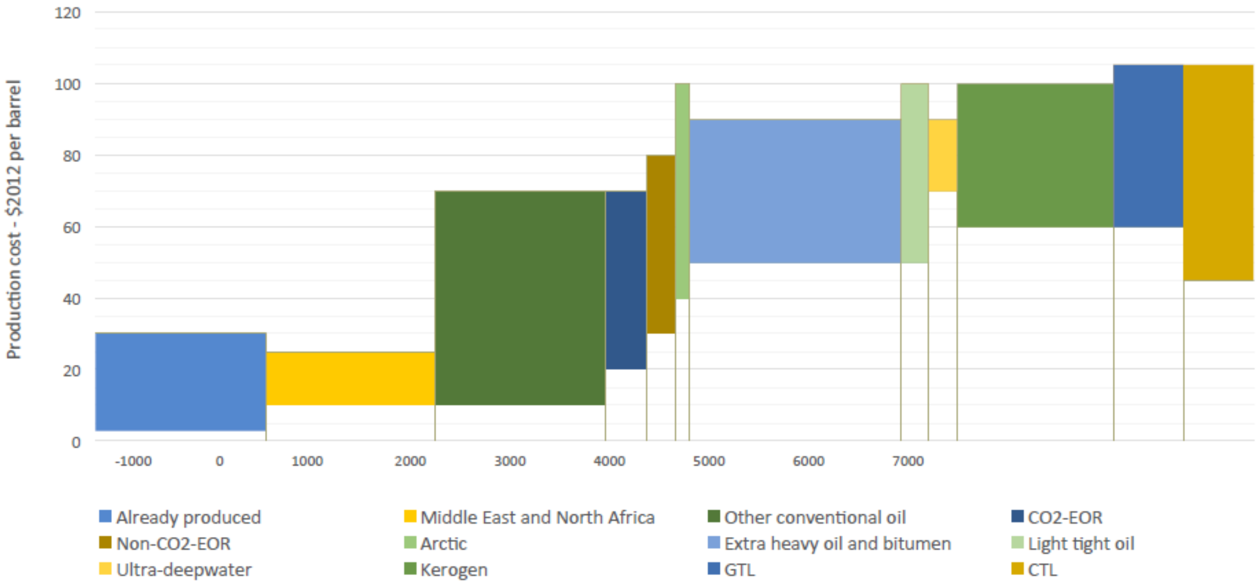
In **Saudi Arabia**, policies play important role not only in shaping the country's oil and gas industry, but they also have the potential to affect the global oil and gas markets due to the country's predominant position in world crude oil reserves, large production and trade. Saudi Arabia is changing its oil policy and output in response to market conditions. In the past, government invested billions of dollars with a goal to maintain spare capacity by developing new projects and upgrading existing ones. In May 2016, the government announced reorganisations in the oil and gas sector (Vision 2030) which seeks to diversify the economy away from reliance on oil. According to IMF, Saudi Arabia obtains more than 90% of its fiscal revenue from oil. Saudi Vision 2030 aims to increase non-oil revenues, privatisation of government enterprises and promoting private sector investments, increasing the role of gas in the energy mix, deploying renewable energy into the power sector, improving efficiency in energy use. These plans are taken by many analysts as clear signs of a drastic shift in the country's energy policy, driving significant structural changes to the governance of the oil and gas sector. (Bassam Fattouh, 2016)

On the other hand, **Russia** is using oil and gas national resources to gain political power. The state has a long history on controlling export and transit of energy resources to Europe. In 2006 and later on 2009, geopolitical tensions between Russia and Ukraine interrupted European gas supplies. Since the annexation of Crimea in 2014, called Ukrainian crisis, political relations between Russia, the EU and the US deteriorated dramatically. Hence, these tensions are likely to change the dynamics of global energy flows. After sanctions imposed on Russia, Europe is searching to diversify its supplies and Russia is seeking new energy markets. This changes the traditional suppliers and consumers in the global energy market. Taking into account the recent developments on the global energy markets (popularization of LNG, shale gas boom, emergence of new entrants) Russia is now negatively affected by change in market fundamentals. U.S. and EU sanctions introduced against Russia, low oil prices and a number of internal factors create adverse conditions for Russian economy and new oil fields development.

Although a tiny country, **Qatar** has exploited its energy resources and gained global influence. Qatar has enabled to emerge as the leading exporter of LNG gaining profits which helped for the nation's economic growth and built a global fleet of LNG tankers. Qatar implemented a moratorium on further exploration and development of the biggest natural gas field more than a decade, so its export capacity has a plateau. In April 2017, Qatar has lifted the self-imposed North Field moratorium and produce 20 bcm of LNG in 5 to 7 years' time is a highly significant development for the LNG industry. The change on the nation's energy policy will no doubt bring significant changes in the LNG market. Qatar can compete with any of the established LNG suppliers flooding the market with its low-cost product. (Rogers, 2017)

Oil price affects oil supply. The availability of resources crucially depends on the level of oil prices. Figure 39 illustrates the production costs for different sources and areas. A sharp rise in oil prices induces an investment response, meaning that it is commercially viable to increase the cost of investment and oil companies turn to develop unconventional resources more expensive to be extracted, therefore it affects oil supply availability. However, if the level of the oil price is very low (below $20 or $25 per barrel), conventional oil fields (Middle East and North Africa shown in Figure 39) become the unique resources which are commercially recoverable.

Figure 39 Supply costs of different fields and resources of liquid fuels



Source: IEA WEO 2013

4.2 Factors affecting oil and gas demand

As analysed in section 1.2 (Global demand), it can be noted that the determinants of demand for oil and gas are the following

- Oil and gas prices. An increase in oil and gas prices normally reduces demand for oil and gas as well as it will reduce economic growth.
- Economic growth. Oil and gas consumption rises usually as a result of high economic growth and energy intensive industries.
- Structural changes in a country's economy. A change in industry from manufacturing to services sector may reduce energy demand.
- Household income. When income declines, total expenditure on oil as percentage of household income declines.
- Car ownership. Transportation contributes largely on oil demand. Thus, if car ownership increases in a country, oil demand will rise.
- Population. An increase in world population could increase demand for energy and in turn oil and gas demand.
- Technology breakthroughs. Technological developments on alternative sources of energy other than fossil fuels increase oil and gas substitution.
- Storage levels. If a country holds large quantities of oil and gas in its inventories, the country is less vulnerable on oil and gas price fluctuations and she is in a stronger position in contrast to countries which do not build inventories. In times of high oil spot prices relative to the future prices, the country do not need to import the expensive oil

of the market, instead the country uses its strategic reserves which lead to a reduction in country's oil demand at the current period.

- Transportation costs. Transportation costs increase or reduce the cost of import which provides disincentives or incentives to import foreign energy products instead of using domestic ones.

4.3 Factors affecting maritime transport

Oil carriers and LNG/LPG carriers transport oil and gas from producer regions to consumer regions. Thus, the demand for oil maritime transport services is derived from the balance between the global supply and demand for crude oil. For instance, an increase in crude oil supply causes an immediate increase in the demand for oil transport services. As it is difficult for shipping companies to immediately respond to the increase in demand by altering their vessels' shipping routes or building new vessels, at least in short-term, it will likely result in higher freight rates when little tanker capacity is available. Similarly, the demand for gas maritime transport services is derived from the balance between the world supply and demand for gas.

In addition, an increase in crude oil prices raises bunker fuel price, being a product from crude oil its price is related to the crude oil price. Bunker fuel is a considerable expense for a shipping company's voyage costs. Thus, transportation cost for shipping companies grows. (Wenming Shi, 2013) As regards changes in gas prices, they do not affect the shipping companies' transportation cost as they do not influence bunker fuel prices.

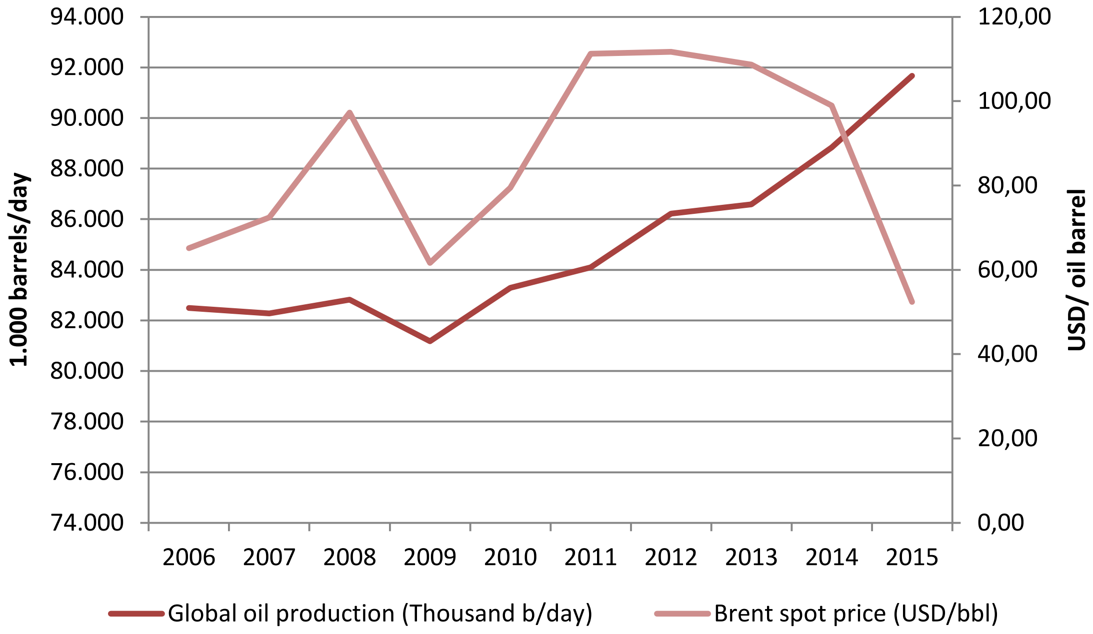
Therefore, it is reasonable to believe that crude oil price shocks as well as changes in oil supply have significant effects on the oil maritime freight market. In the case of gas, conventional wisdom says that gas supply changes bring about volatility in gas prices and gas maritime transport services. However, gas prices themselves do not affect gas maritime transportation costs but they are rather affected by crude oil prices. Furthermore, changes which transform the internal market of the main players of oil and gas industry have global implications in the world trade which in turn affect the maritime transport services. These changes have the potential to completely alter the picture of future global oil and gas supply and trade flows of liquid energy goods.

According to paper (Wenming Shi, 2013), a significant number of studies examined the determinants of tanker freight rates as well as a huge body of literature evaluated the linkage between oil price volatility and macroeconomic variables. However, there are only a small number of studies which examine the relationship between crude oil market and crude oil tanker freight market. A recent study (Wenming Shi, 2013) that was previously referred focuses on the relationship between fluctuations in crude oil prices in the international market and freight rates in the tanker market using a structural vector autoregressive (SVAR) model. It distinguishes crude oil price shocks into crude oil supply shock, crude oil non-supply shock and other shocks. They examine the significance and the magnitude of its effect on the tanker market using the impulse response analysis. Their findings are that the 'supply shock' has a direct effect on the tanker market but not the non-supply shock. A 'non-supply shock' significantly raises the crude oil prices which brings about higher tanker transportation costs. The 'other shock' has an immediate and positive effect on the crude oil tanker market levels which implies that some important things are missing in their model, such as new regulations for the crude oil transport services. (Wenming Shi, 2013)

Figures 40 and 41 present historical annual data of global crude oil production, crude oil price and oil tanker freight rates. Comparing the two variables on figure 40, they follow a parallel trajectory with the crude oil price to appear more sharp increases and decreases. However, since 2014 they follow a reverse direction, crude oil production continued to increase while crude oil prices fell. The conventional wisdom says that an increase in crude oil production necessarily causes lower crude oil prices according to the laws of supply and demand. On the contrary, non-OPEC producers (representing 60% of world oil production) are regarded as price takers, meaning that they respond to market prices rather than attempt to influence prices by managing production. (U.S. Energy Information Administration, n.d.) In fact, non-supply factors may affect crude oil prices such as wars, OPEC countries, dollar depreciation, consumer confidence, oil derivatives and the demand for oil caused by rapid economic growth of developing countries.

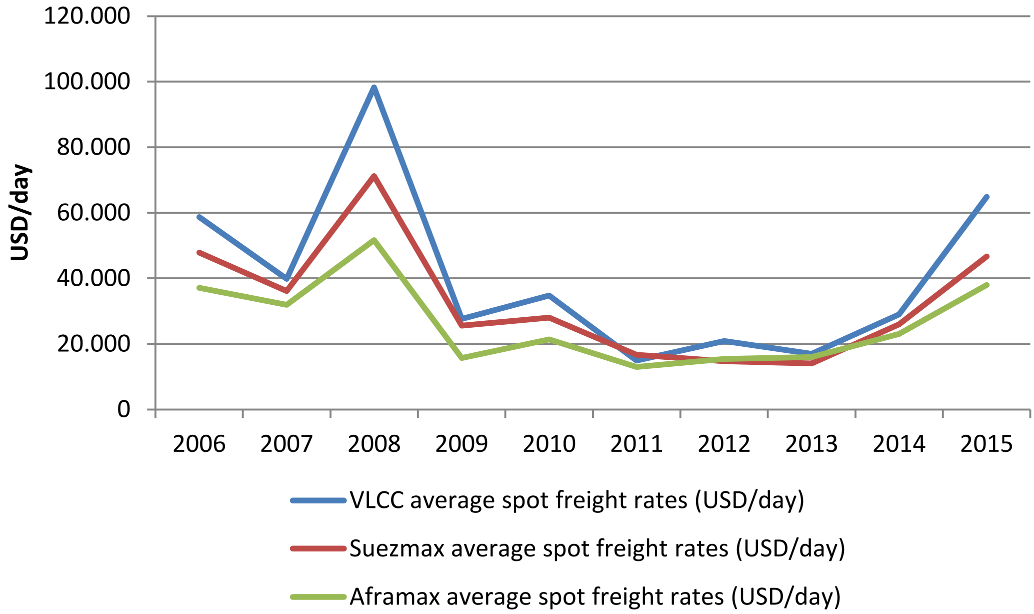
Comparing the evolution patterns of the three variables in figure 40 and 41, it seems that a similar decrease tendency occurred from the second half of 2008 to the begging of 2009. A decline in crude oil prices decreased transportation costs in the tanker market. Low crude oil tanker freight levels were caused by a significant fleet growth and a combination of drop in OPEC crude oil production as well as decline in OECD oil consumption caused by the negative consequences of financial crisis, resulting to a decrease in the demand for crude oil transport services. Hence, the imbalance of demand and supply for crude oil transport services deteriorated. On the contrary, during the period 2010-2013 when crude oil production and crude oil prices recorded remarkable increases on year-over-year basis along with bunker prices which increased transportation costs, tanker freight rates were gradually falling and tanker earnings were under pressure. Although, there was strong crude oil production, low crude oil demand did not favoured trade and extensive fleet oversupply worsened freight market levels. (Christopher Rex, 2011) Since 2014 crude oil prices collapsed, while crude oil production continued to expand, freight prices started to rise. China boosted its crude oil imports resulting to an increase in demand for oil transport services in combination with a slower fleet growth which narrowed the imbalance between supply and demand in the freight market. (Christopher Rex, 2014) The crude oil market has been in 'contango', which means that oil traders' incentives increase for oil storage, including floating storage which increases demand for tankers.

Figure 40: **Historical data of oil production and Brent spot price.**



Source: BP Statistical Review of World Energy June 2016.

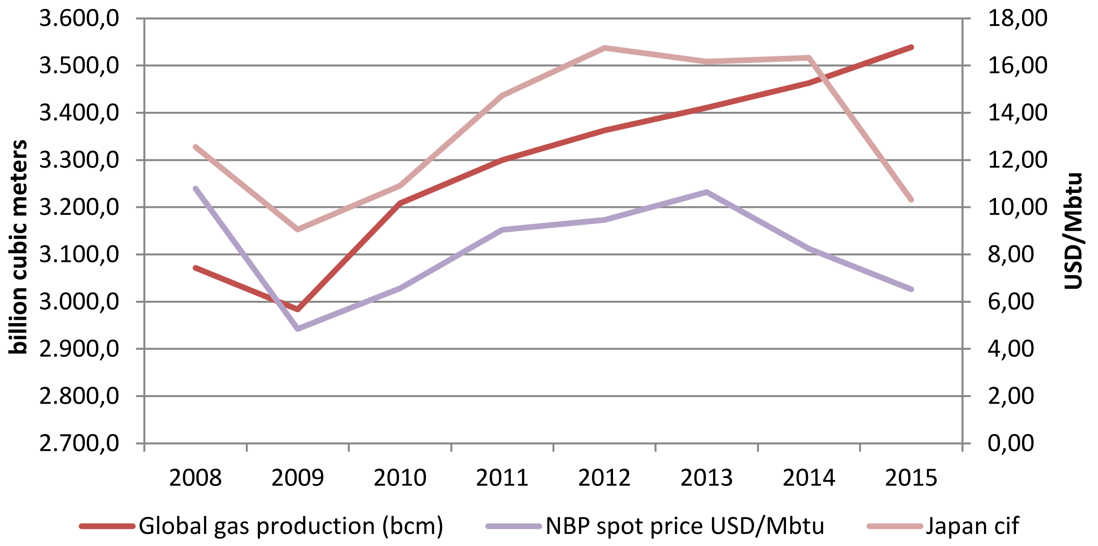
Figure 41: **Historical data of oil tanker freight rates.**



Sources: The Platou Report various issues (RS Platou 2007, 2009, 2013, 2015), UNCTAD 2016.

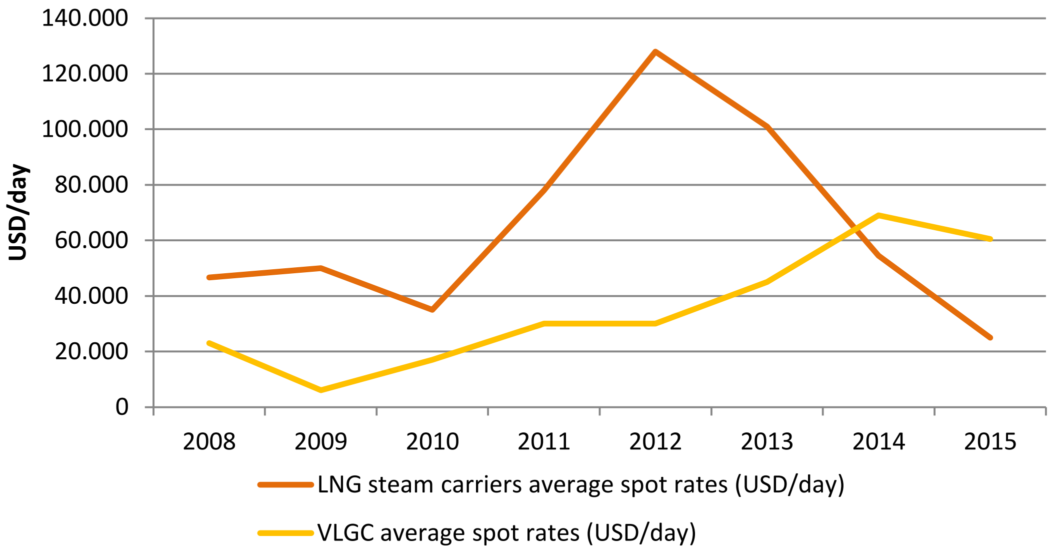
Figures 42 and 43 illustrate historical annual data of global gas production, gas price and gas carrier freight rates. Because gas market is fragmented, as noticed in previous sections, gas prices are not shaped completely as a result of market fundamentals or changes in gas production, yet they are linked to crude oil price. Gas prices present similar fluctuations over the sampled years to crude oil prices with different magnitude and lag in increases and decreases.

Figure 42: **Historical data of global gas production and NBP spot price.**



Source: BP Statistical Review of World Energy June 2016.

Figure 43: **Historical data of LNG & LPG carrier freight rates.**



Sources: The Platou Report various issues, Danish Ship Finance 2015-2016.

Combining the three variables in figures 42 and 43, it is firstly noticeable that the evolution patterns of the LNG and LPG carrier freight rates are following different routes, because of the different commodities that they transport. LNG carriers transport natural gas whereas LPG carriers transport petroleum gas, which is an oil product. In addition, as LNG trade is mostly spread in Asian markets, demand for gas transport services is affected by the balance of the Asian gas supply and demand. LNG demand growth boosted by China, South Korea, Taiwan and India in the post 2009 economic recovery period resulted in a 'tight' Asian gas market while the limited capacity of LNG carriers leading to rising freight rates for LNG carriers. (Rogers, 2015) During the period 2011-2013, Japan's gas imports dominated LNG trade caused by increased demand due to the shutdown of nuclear generation caused by Fukushima disaster in March 2011. LNG price differential in Atlantic and Pacific basins widened caused arbitrage opportunities to increase which in turn increased journey lengths (sending cargoes from Atlantic basin and Middle East into Asian markets) resulting in greater demand for LNG carriers.

(International Gas Union, 2011) Furthermore, as previously observed on figure 40, crude oil price during 2011-2013 was high which increased gas transportation cost for shipping services. Since 2013, a drop in LNG supply which led to lower freight rates was associated with unscheduled outages at key LNG export plants. (International Gas Union, 2014) Although, there was a firm LNG demand coming from Asia in 2014, LNG fleet growth was keeping LNG spot charter rates trended downward. (International Gas Union, 2015) LNG charter rates continued their downward trajectory in 2015 as fleet oversupply outpaced LNG demand. (International Gas Union, 2016)

Combining the variables in figures 40 and 43, the evolution patterns of LPG carrier freight rates are correlated to global oil production and crude oil prices, transporting a crude oil product. In the aftermath of financial crisis, LPG charter rates suffered due to low LPG demand. Since 2010, seaborne LPG demand increased, driven by Asia, in tandem with global oil production, LPG consumption and crude oil prices resulting, while fleet growth was limited resulting in recovered LPG charter rates. (Christopher Rex, 2011) In 2011, LPG exports rose in the Middle East due to increased LPG production from Saudi Arabia and sufficient demand from Asia which pushed LPG freight rates higher as demand for LPG carriers increased. Rising crude oil prices also increased transportation costs during the period. (Christopher Rex, 2012) In 2012, a temporary slowdown in LPG freight rates occurred as a result of unexpected changes in refineries and delayed winter demand. (Christopher Rex, 2013) During 2013-2014, LPG freight rates reached record highs as Asian demand was sufficient to outpace increased fleet growth. (Christopher Rex, 2014) (Christopher Rex, 2015) However, in 2015 the market situation has changed since rapid LPG carrier supply growth and slower demand growth led to declining LPG freight rates.

To conclude, the crude oil tanker freight market seems to be mostly influenced by market fundamentals, that is the balance between demand and supply for shipping service (i.e. the demand for shipping is seaborne trade for crude oil and supply of shipping service is fleet size in the crude oil tanker shipping market). It is also significantly affected by the crude oil market, meaning the demand and supply of crude oil as a commodity, which affects seaborne trade and in turn demand for crude oil transportation. Crude oil prices seem to indirectly affect crude oil tanker market; when low crude oil prices increased demand for crude oil commodity, demand for crude oil tankers also increased.

Obviously, demand for LNG transport services is shaping as a result of combination of LNG tanker market and LNG market fundamentals affected by the crude oil price volatility. Although, crude oil prices decreased since 2014, meaning that transportation costs are lower for shipping companies, LNG freight rates continue to decline as a result of LNG shipping market fundamentals. In addition, natural gas prices indirectly influence the LNG charter market, as LNG price affects LNG imports which require transportation. When LNG price differential widen, incentives for traders' arbitrage increase resulting in greater demand for LNG carriers.

As far as LPG carrier market is concerned, is driven by LPG supply rather than demand. LPG tanker market is affected by LPG tanker market fundamentals as well as demand and supply for LPG. LPG freight rates seem to be related with crude oil prices' increases and decreases. Although, crude oil prices decreased since 2014, meaning that transportation costs are lower for shipping companies, LPG freight rates were high, influenced by LPG shipping market fundamentals.

5. Conclusions

The purpose of the above analysis was to examine how the global liquid energy market interacts with the global maritime transport market of liquid energy commodities, the factors affecting the two markets, the trends that currently prevailing and the prospects for growth in the future.

The **first section** focused on the global market for liquid energy products. In particular, global oil and gas reserves have been examined, as well as their distribution and evolution over the last decade. The main findings of the analysis are summarized below.

Concerning oil market, it is concluded that oil consumption and oil production are unevenly distributed across the world. The majority of the world's oil consumption is located in North America, Europe & Eurasia and Asia & Pacific, whereas the majority of the reserves are located in the Middle East and South & Central America. The regional distribution of natural gas consumption and production is more balanced between continents than the regional distribution for oil. Natural gas prices and markets are segmented. In Asia Pacific region is mainly traded by LNG, while Russian-Europe and North America trade is dominated by pipeline. Among the fossil fuels there is a global trend in favor of natural gas. On the one hand, natural gas is the fossil fuel with lowest carbon intensity. On the other hand, due to the "shale gas boom" in the USA and an expanding infrastructure for liquefied natural gas (LNG), there is a stable outlook for gas supply. Nevertheless, the global potential of shale gas is still disputed.

Different scenarios exist for the projection of the future and the outcome of global energy demand and supply. BP's energy outlook (British Petroleum, 2016) highlights that by 2035, world energy demand will grow by 41% with a slower growth rate. This growth will come almost entirely from the emerging economies; their share will be 95%. Power generation will account for more than half of growth. Transport will be the slowest-growing sector, which will use natural gas, biofuels and electricity, but still will be dominated by oil. India will have faster growth in energy consumption than China, but the latter will still import and consume the most. The US will achieve energy self-sufficiency. Energy efficiency levels will improve worldwide, therefore rising economic growth will mean flattening energy demand.

Further to BP's estimations, fossil fuels will remain dominant in the global energy use by 2035, contributing a share of 81%, whereas it will be less according to EIA's (U.S. Energy Information Administration, 2016) estimation of 78% in 2040, compared to their 86% share in 2012. Oil will continue to lose ground and growth in demand for oil (0.9% p.a.) will be mainly met by the tight oil US production and OPEC. Today's imbalance of demand and supply will correct over time. Natural gas will be the fastest-growing fossil fuel (1.8% p.a.) and much of the production growth will come from shale gas.

The recent IEA Gas Market Report (International Energy Agency, 2016) predicts the outlook of natural gas in the medium-term (until 2021). Low prices and sharp cutback in investments result in slower growth in global gas production over the next five years. EIA (U.S. Energy Information Administration, 2016) assumes that the world's gas producers increase supplies by nearly 69% from 2012 to 2040. The largest increases in natural gas production during the period occur in non-OECD Asia, Middle East, OECD Americas, China, US and Russia. In the United States, production is expected to increase by more than 100 bcm between 2015 and 2021, accounting for one-third of global incremental production. Production growth from Russia and the Caspian region, the world's largest exporting region, slows to half the level recorded between 2009 and 2015. Weak demand in Europe and slower consumption growth in China, the two key export outlets for Russian and Caspian volumes, weigh on the region's production outlook. BP (British Petroleum, 2016) foresees that the increase in global gas supply will be roughly split between conventional and shale gas production by 2035. Traditionally growth in shale output stems from the US; however by 2035 China will be the largest contributor to growth in shale gas production according to BP (British Petroleum, 2016).

In the international gas trade, the share of LNG grows substantially by 2040; surpassing pipeline imports as the dominant form of traded gas. IEA (International Energy Agency, 2016) and BP (British Petroleum, 2016) assumptions agree that global LNG export capacity is forecasted to increase by 45% between 2015 and 2021, 90% of which originates from the United States and Australia. In Europe, as many contracts with Russia are coming to an end in early 2020s, there will be exactly the time when a lot of LNG quantities will come into the market. Oversupply in global LNG markets will lead to fierce competition, with flexible US and Qatari volumes set to fight hard to gain access to European customers.

The main scenario of IEA's World Energy Outlook of 2016, forecasts that global energy demand will rise 30% in 2040 as global GDP grows, compared to the increase of 60% during the last 25 years. EIA (U.S. Energy Information Administration, 2016) sees even larger increase of 48% in 2040. This assumption of IEA for the next 25 years agrees with BP, about the global energy demand is due to increased efficiency improvements, which also affects oil and gas demand.

The main conclusion of the analysis of the first section is that global markets for oil and gas will grow strongly in the next decades.

The **second section** analyzed the maritime transport of liquid energy goods and their international transport system. The major conclusions of this study are as follows:

Seaborne trade of energy goods is dominating bulk shipping. As of 2006, this group of commodities, which share accounts for 44% of the total tonnage of seaborne trade, comprises crude oil, oil products, liquefied gas and thermal coal. Excluding coal, the trade of liquid energy commodities has experienced the largest growth out of the group of bulk commodities in 2015. Crude oil shipments are estimated to have increased by 3.8% in 2015. Petroleum products and gas trade together expanded by 5.2% in 2015, rise up from 2.6% in 2014.

There is a diverse fleet of tankers which transport crude oil, oil products, chemicals, liquid gases and specialist cargoes. The oil tankers transport crude oil and oil products. The specialized tankers transport liquefied natural gas (LNG) and liquefied petroleum gas (LPG).

In 2015 there were transported approximately 8 billion tons of bulk commodities, around 80% of the total sea trade. This total included 2.9 billion tons of liquid commodities that are oil and gas, and represents more than a quarter of the total seaborne trade. Global seaborne crude oil trade expanded faster than oil demand in 2015 and reversed the downward trend of 2014 due to a number of important factors. Crude tankers demand was held back during the year 2016 in contrast to the previous year, as oil prices started to show signs of upward movement, limited expansion in refinery capacity, high oil inventories and sluggish economic growth.

The world fleet grew by 3.5% from 2015 to January 2016 in terms of deadweight tons (dwt). This is the lowest growth rate since 2003, yet still higher than the 2.1% growth in demand, leading to a continued situation of global overcapacity.

Average tanker earnings per vessel rose to an average of USD 31,036 per day, an increase of 73% over 2014, the highest level since 2008. In terms of profits and trade for oil tankers 2015 was one of the best years. The gap between crude tanker supply and demand narrowed, while the fundamental gap of product tanker supply and demand widened. The crude tanker fleet grew by 2%, while seaborne crude oil volumes increased by 4% during 2015. However, overall supply, i.e. crude and product tanker shipping capacity, increased faster than demand, i.e. crude and product oil trade volumes in 2015, leading to overcapacity being the situation for the rest segments of the shipping industry. The situation of overcapacity continued during the year 2016. Crude tanker demand and product tanker demand increased by 3% and 4% respectively, whereas both crude and product tanker supply have increased each by 6% in 2016. Hence, the balance between tanker demand and supply has deteriorated during 2016.

Danish Ship Finance (Christopher Rex, 2016) anticipates that overcapacity, lower freight rates and lower secondhand prices will continue the next 2 years for crude tankers. Growth in trade volumes is expected to be moderate, while the Crude Tanker fleet is set to expand by more than 4% p.a. up to 2018. On the one hand, this growth in trade can be explained by the limited oil demand, which in the medium-term is expected to grow by an average of just 1% p.a. until 2021. On the other hand, regarding the Crude Tanker fleet surplus in supply, the fleet is young and growing, while the order book corresponds to 16% of the fleet which are scheduled to be delivered within the next 2 years.

The fleet of LPG tankers was about 1,000 LPG tankers in 2006, while the fleet evolved into 1,327 vessels as of January 2016. The fleet of LNG tankers expanded from 193 ships with another 140 on order in 2006 to 449 vessels at the start of 2016. Almost 63% of the vessels are younger than 10 years at the end of 2015. Currently, the cargo capacity of LNG tankers is focused between 90,000 and 170,000 cm. Although LNG carrier fleet owns a small number of vessels, it holds more than twice the capacity of LPG carriers. That is because of the large size that LNG carriers are being built. In particular, LPG carriers were 1,327 with capacity 25.8 million cm as of 2016, whereas LNG carriers were only 443 having 64.6 million cm in terms of capacity.

LNG tanker demand and therefore LNG trade increased by 3.5% in 2015. Global traded LNG volumes reached 338.3 bcm in 2015, a historical high for total trade in the LNG market. Export growth was driven by Australia, Indonesia, Malaysia, Papua New Guinea and Qatar, while import demand was raised by Middle East, Europe and western Asia, i.e. China and India, as Japan is slowing its imports. United States increased its LNG imports by over 50%, while exports increased eightfold in 2015. In July 2015, 19 countries were exporting LNG and 16 countries have started importing LNG over the past 10 years (34 importing countries in total). As regards the LPG tanker demand, trade has expanded by 8.3% in 2015, owing to continued export growth in the United States and rising demand in the petrochemical and household sectors in Asia, notably in China and India. On the supply side, although gas carriers represent only 3% of the total world fleet in terms of dwt of 2016, the highest growth (9.67%) was recorded for gas tanker fleet from 2015 to 2016 compared to the other fleet segments.

In short, LPG market showed exceptional strength during 2015, whereas LNG market remained at low levels since mid-2015. The transported LPG/LNG volumes reached 327 million tons in

2015, while in 2016 recorded approximately 339 million tons due to the development of new offshore gas fields. The global oversupply of LPG has caused the price spread between regions to narrow and turned the market from being demand-driven to supply-pushed. Similarly, in the LNG market, oversupply of LNG has put pressure on the LNG prices and transformed the market. The supply and demand gap in the LPG tanker market has continued to widen in 2016.

Danish Ship Finance (Christopher Rex, 2016) predicts that low freight rates and secondhand prices are expected to continue the next 2 years for LPG tankers. However, limited placement of new orders and steady growth in LPG demand could lead to a market recovery beyond 2018. On the demand side, LPG trade volumes are expected to grow by more than 5% per year over the next 5 years. It is expected that Asia will remain the main driver for seaborne LPG trade. Based on IEA's predictions, providing that US shale oil production will continue to grow in the next years (LPG accounts for a large part of the retrieved shale oil volumes), US LPG exports would be boosted. As regards the supply forecasts, the order book currently equals 22% of the fleet, indicating significant expansion over the next 3 years.

Regarding LNG tanker demand, LNG trade is expected to dominate global gas long-distance trade; its share is set to increase to 53% by 2040 at the expense of pipeline. On the supply side, the trend for larger LNG vessels continues on the new placed orders. Based on the current order book, the average ship capacity is set to increase to 175,000 cm (+7%) by 2020, compared to 164,000 cm in 2015. IGU (International Gas Union, 2016) expects that oversupply will persist given the additional tonnage.

Shipping contributed to the global trade evolution by making the cost of freight so small, representing only a small proportion of the total value of world trade, therefore sea transport cost is not anymore a major issue in deciding where to source goods. In fact, oil cost little more to transport in 1990s than 50 years earlier. In 1949, the shipping cost was $0.50 per barrel, while during the 2004 boom the cost went up to $3.37 per barrel. However, Stopford (Stopford, 2009) emphasizes that compared to the other sectors of economy, shipping business achievement was to maintain costs low when the cost of commodities it carried increased by 10 or 20 times. Economies of scale played a major role in keeping sea transport costs low. Over the years, average size of ship in each shipping segment tends to increase. Ship transport costs are driven up and down by the freight market. When economic conditions or random shocks change the outlook of the global trade, it takes time for the shipping industry to adjust; by either altering the capacity of ships in service or producing new ones. As a result, shipping costs are volatile. Furthermore, tanker shipping costs are seasonal because demand for crude and product tanker service is seasonal.

The last decade, the gradual decline in the cost structure in the entire LNG chain has enable LNG to compete with piped gas.

The **third section** concerned about the modern institutional framework governing maritime transport of liquid energy goods as well as recent developments. In particular, it refers to the international framework enforced by International Maritime Organization (IMO), European policies on shipping and the Greek institutional framework.

The regulatory environment in which tankers operate is one common characteristic that affects all segments of the tanker market and is becoming increasingly significant.

The last decades, especially after World War II, it has been noticed an intensification of marine pollution. Several marine accidents are considered landmarks for legislation. These accidents provoked a public outcry and the increasing environmental awareness of society has led to the tightening of the marine and especially the tankers' regulatory environment. The goal of maritime regulators is to close the net and ensure that shipping companies operate within the same standards of safety and environmental responsibility which apply on land. In the last 50 years the regulatory regime has played a significant part in the economics of the shipping market. During the last decade, international, European and national regulators have given emphasis on matters such as environment, emissions by ships, ballast water, and ship recycling.

The **fourth section** discussed the determinants that influence the international market for liquid energy products on the demand and supply side. It then examines how the energy market affects maritime transport market by analysing historical data of three variables: world annual output, commodity price and freight rate.

As far as oil and gas supply is concerned, changing developments in domestic market of the main energy actors are likely to affect the global oil and gas industry. In terms of supply, the key energy market players are U.S.A, Saudi Arabia, Russia, Qatar, OPEC and National Oil Companies. Oil price affects oil supply. The availability of resources crucially depends on the level of oil prices. A sharp rise in oil prices induces an investment response, meaning that it is commercially viable to increase the cost of investment and oil companies turn to develop unconventional resources more expensive to be extracted, therefore it affects oil supply availability. However, if the level of the oil price is very low (below $20 or $25 per barrel), conventional oil fields (Middle East and North Africa) become the unique resources which are commercially recoverable.

The factors affecting oil and gas demand are economic growth, household income, car ownership, industrial output, population and the maritime transport market. Oil carriers and LNG/LPG carriers transport oil and gas from producer regions to consumer regions. Thus, the demand for oil maritime transport services is derived from the balance between the global supply and demand for crude oil. For instance, an increase in crude oil supply causes an immediate increase in the demand for oil transport services. As it is difficult for shipping companies to immediately respond to the increase in demand by altering their vessels' shipping routes or building new vessels, at least in short-term, it will likely result in higher freight rates when little tanker capacity is available. Similarly, the demand for gas maritime transport services is derived from the balance between the world supply and demand for gas. In addition, an increase in crude oil prices raises bunker fuel price. Bunker fuel is a considerable expense for a shipping company's voyage costs. Thus, transportation cost for shipping companies grows. As regards changes in gas prices, they do not affect the shipping companies' transportation cost as they do not influence bunker fuel prices.

Furthermore, changes which transform the internal market of the main players of oil and gas industry have global implications in the world trade which in turn affect the maritime transport services. These changes have the potential to completely alter the picture of future global oil and gas supply and trade flows of liquid energy goods.

The crude oil tanker freight market seems to be mostly influenced by market fundamentals, that is the balance between demand and supply for shipping service (i.e. the demand for shipping is seaborne trade for crude oil and supply of shipping service is fleet size in the crude oil tanker shipping market). It is also significantly affected by the crude oil market, meaning the demand

and supply of crude oil as a commodity, which affects seaborne trade and in turn demand for crude oil transportation. Crude oil prices seem to indirectly affect crude oil tanker market; when low crude oil prices increased demand for crude oil commodity, demand for crude oil tankers also increased.

Obviously, demand for LNG transport services is shaping as a result of combination of LNG tanker market and LNG market fundamentals affected by the crude oil price volatility. Although, crude oil prices decreased since 2014, meaning that transportation costs are lower for shipping companies, LNG freight rates continue to decline as a result of LNG shipping market fundamentals. In addition, natural gas prices indirectly influence the LNG charter market, as LNG price affects LNG imports which require transportation. When LNG price differential widen, incentives for traders' arbitrage increase resulting in greater demand for LNG carriers.

As far as LPG carrier market is concerned, is driven by LPG supply rather than demand. LPG tanker market is affected by LPG tanker market fundamentals as well as demand and supply for LPG. LPG freight rates seem to be related with crude oil prices' increases and decreases. Although, crude oil prices decreased since 2014, meaning that transportation costs are lower for shipping companies, LPG freight rates were high, influenced by LPG shipping market fundamentals.

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