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ENERGY CARGOES TRADE FLOWS

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DECLARATION OF AUTHENTICITY

I, the undersigned, Stefanos Kamtsiklis, declare that this dissertation is my original work, gathered and utilized especially to fulfill the purposes and objectives of this study, and has not been previously submitted to any other university for a higher degree. I also declare that the publications cited in this work have been personally consulted.

THREE -MEMBER COMMITTEE

"This mater thesis was approved unanimously by the three-member committee appointed by the Special General Assembly in accordance with the operating regulations of the Master Science Programme in Shipping. The members of the Committee are:

Professor Stratos Papadimitriou (supervisor)
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The approval of the master thesis by the department of Maritime Studies, University of Piraeus does not imply endorsement of the author's opinion."

ABSTRACT

LNG (liquefied natural gas), crude oil and its distillates have been playing a major role in the formation of global flows of energy through intermodal transportation. The subject of this thesis is to point out the global flows of energy cargos and also to provide data of any future change on the transportation work of all means involved. In the first chapter there is the presentation of the structure of the LNG market and the presentation of the current global trade flows. In the second chapter, which is about crude oil, an analysis of crude oil market is processed and its trade flows are presented. The same motive is followed in the third chapter, which refers to refined petroleum products. The fourth and last chapter of this master thesis examines the impact of the trade flows of the afore-mentioned cargoes on global trade and charter rates and presents the possible credibility in particular types of vessels.

Acknowledgements

I would like to thank Professor Stratos Papadimitriou for all of his guidance and assistance throughout this process. Without his hard work and dedication this thesis would not have been possible. I would also like to express my deepest gratitude to my family who have encouraged and supported me emotionally and financially through this educational experience.

Athens, September 2014

Stefanos Kamtsiklis

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LIST OF ACRONYMS AND ABBREVIATIONS

b	barrel
bcm	billion cubic meters
BTU	British Thermal Units
CAGR	Compound Annual Growth Rate
CCG	Cat Cracked Gasoline
CIS	Commonwealth of Independent States
CNG	Compressed Natural Gas
DOE	Department of Energy
Dwt	Deadweight
EIA	Energy Information Administration
GDP	Gross Domestic Product
IGU	International Gas Union
kb	thousand barrels
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRCC	Long Residue Catalytic Cracking
mb	million barrels
mt	million tons
MT	Metric Tons
MTPA	Metric Tons per Annum
nmi	nautical miles
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
p.a.	per annum

UAE United Arabic Emirates

INTRODUCTION

The transportation of fuels is quite critical for the global trade and economy. Various means of transportation have been being used through this complex process, vessels being the most economic efficient for long haul means and also pipelines, rail, and specialized trucks. The global distribution of LNG and crude oil inventories formulates the global flows of fuels and the efficiency and effectiveness of the supply chain as long as the price of the aforementioned energy cargoes.

In the advent of time the LNG has been capturing a larger share of the world's energy demand. LNG has been known since the Industrial Revolution and lately has been a major rival to coal and oil and according to many statistical reviews such as BP and GE statistical review, gas will grow by more than a third over its current global consumption by 2025. According to International Gas Union Report 2014, natural gas accounts for ~1/4 of global energy consumption. LNG has been the fastest growing source of gas supply (+7% per year since 2000) and now meets 10% of global demand. LNG is uniquely positioned to take a more commanding share of future gas consumption. Crude oil is the most popular resource and it is widely used in many sectors. Crude oil, a commodity whose price is affected by the supply and demand rules, is the only source for all refined petroleum products except for LPG. Refined petroleum products are widely used in transportation, energy, industrial and agricultural sector.

Global economic growth, trade growth, wars and conflicts between nations, political stability in commodity producing countries, embargoes against countries and developing countries like China and India with high energy demand are some factors which are going to determine the global flows of energy cargoes.

Ship-owners and generally individuals related to shipping industry need to be aware of the global flows of energy cargoes in order to take the right decisions on where to position their vessels or in what kind of vessel to invest in.

LNG MARKET AND ITS GLOBAL FLOWS

WHAT IS LNG?

When natural gas is cooled to a temperature of approximately -260°F [-160°C] at atmospheric pressure it condenses to a liquid called **liquefied natural gas (LNG)**. One volume of this liquid takes up about 1/600th the volume of natural gas at a stove burner tip. LNG weighs less than one-half that of water, actually about 45% as much. LNG is odorless, colorless, non-corrosive, and non-toxic. When vaporized it burns only in concentrations of 5% to 15% when mixed with air. Neither LNG, nor its vapor, can explode in an unconfined open environment. Natural gas is composed primarily of methane (typically, at least 90%), but may also contain ethane, propane and heavier hydrocarbons. Small quantities of nitrogen, oxygen, carbon dioxide, sulfur compounds, and water may also be found in "pipeline" natural gas. The liquefaction process removes the oxygen, carbon dioxide, sulfur compounds, and water. The process can also be designed to purify the LNG to almost 100% methane (www.ch-iv.com).

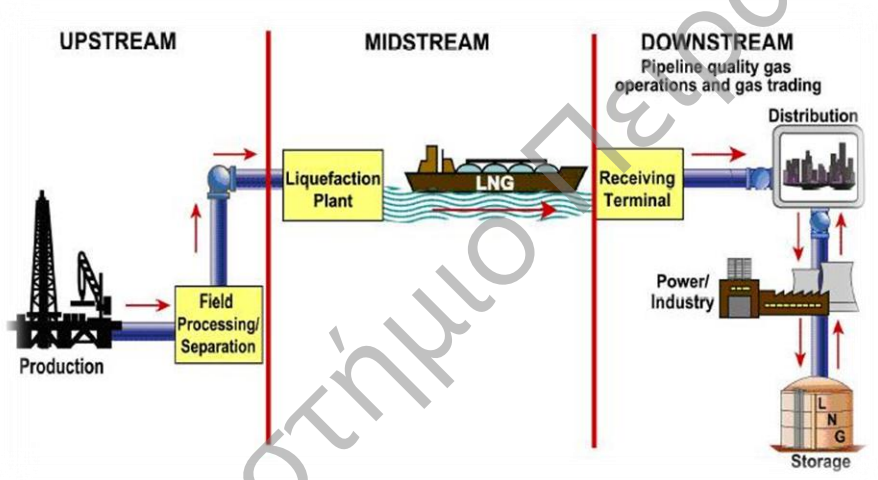
LNG PRODUCTION PROCESS

Global energy demand is expected to double by 2050 compared to 2000. To help meet this demand, gas will form an increasingly important role. Natural gas is plentiful, and it's the cleanest-burning fossil fuel. But some natural gas resources are in remote locations: transporting the gas long distances by pipeline can be costly and impractical. The solution? The gas is liquefied through cooling, a procedure which shrinks its volume for easier, economical and safe transportation by ship. Natural gas extracted from the ground, contains impurities, water and other associated liquids. First it is processed to clean it. It goes through a series of pipes and vessels where gravity helps separate the gas from some of the heavier liquids. Other impurities are then stripped out. The natural gas passes through a water-based solvent that absorbs carbon dioxide CO_2 and hydrogen sulfide H2S. These would otherwise freeze when the gas is cooled and so cause blockages. Next any remaining water is removed, as this would also freeze. Finally, remaining lighter natural gas liquids- mainly propane C3H8 and butane C4H10- are extracted to be sold separately or used as a refrigerant later in the cooling process. Traces of mercury Hg are also filtered out. Now the purified natural gas- methane CH4 with some ethane C2H6- is ready to

be liquefied. This happens in heat exchangers. A coolant, chilled by giant refrigerators, absorbs the heat from the natural gas. It cools the gas to -162^{o}C, shrinking its volume by 600 times. This turns it into a clear, colorless, non-toxic liquid- liquefied natural gas or LNG- that it is much easier to store and transport. The LNG is kept in insulated tanks until it is ready for loading into a specially designed LNG ship or carrier. When the ship arrives at its destination, the LNG is transferred to a re-gasification plant, where it is heated, returning to its gaseous state. The gas is then transported by pipelines to customers, providing energy for homes and industry (Shell).

Additionally, to the last stage of distribution to customers, except for pipelines, specialized trucks are used for the transport of LNG to customers.

Figure 1.1: The LNG Supply Chain



source: http://www.goldwater.it/news.php?lang=it&codice=1 (visited May 10, 2014)

AN OVERVIEW OF THE LNG MARKET IN 2013

According to International Gas Union Report 2014, global LNG trade remained stable in 2013. Exports reached 236.8 MT in 2013, nearly on par with 2012 levels though still below the peak of 241.5 MT reached in 2011. Historically, the Asia Pacific region (Brunei, Indonesia, Malaysia and Australia) have been the world's most important LNG suppliers; but they have been supplemented and, ultimately, surpassed by the Middle East as Qatar, in particular, became the world's largest LNG supplier in the mid 2000's.

In 2013, the Middle East supplied 42% of the world's LNG, while Asia Pacific provided 30%. On the demand side, the Asia Pacific region continued to show the most substantial growth (+7.7 MT), driven by higher levels of consumption in South Korea and China. Conversely, sustained demand weakness in Europe saw LNG

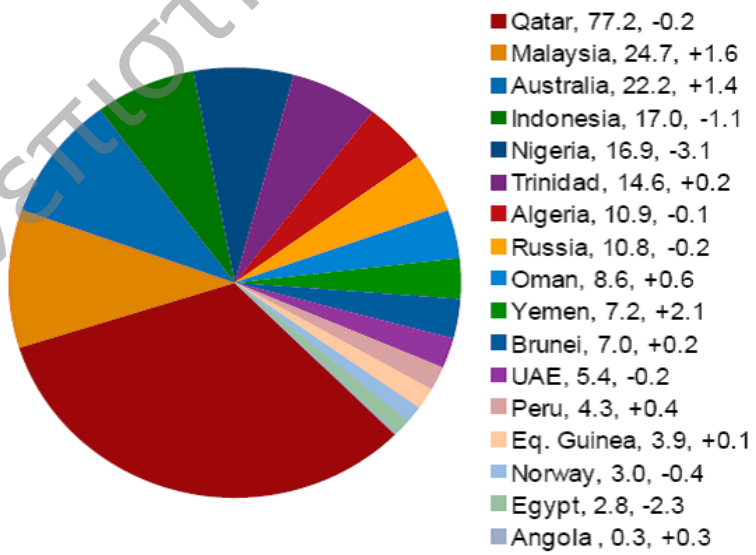
imports fall by 14.6 MT, with Spain, the UK and France witnessing the most substantial drops in consumption (IGU a).

WORLD'S TOP LNG SUPPLIERS AS PER 2013

Seventeen countries were the major players in the exporting trade of LNG as of 2013. The greatest quantities of LNG exports can be seen at the area of Saudi Arabia Peninsula, a region rich in oil reserves too, including Qatar, Oman, Yemen and U.A.E.

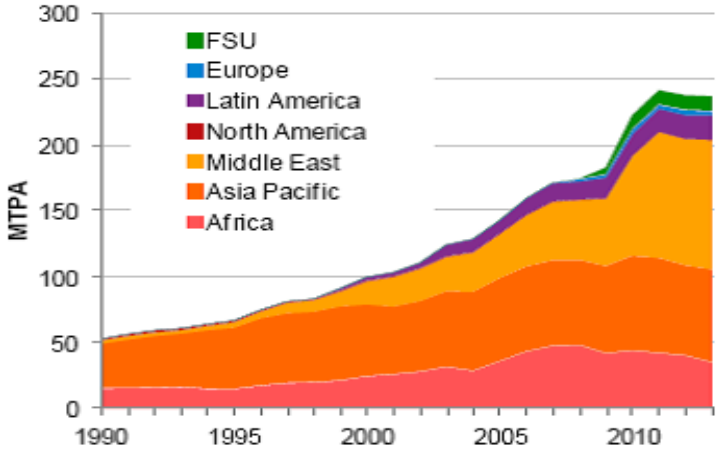
The Asia Pacific region has been the world's most important source of LNG. Yet Asia Pacific exports have been supplemented and, ultimately, surpassed by the Middle East since 2006. This growth is largely dependent on developments in Qatar, where liquefaction capacity surged from 25.5 MTPA in 2006 to 77.0 MTPA in 2011 (IGU b). Malaysia, Australia, Indonesia and Brunei hold a significant share of global LNG exports. Some other countries with great shares at the global LNG export market are: Nigeria, Trinidad, Algeria, Russia, Peru, Eq. Guinea, Norway, Egypt and Angola.

Figure 1.2: 2013 LNG Exports by Country & Incremental Change Relative to 2012 (in MTPA)



Sources: IHS, US DOE, IGU report 2014 p.8

Figure 1.3: LNG Exports by Region, 1990-2013



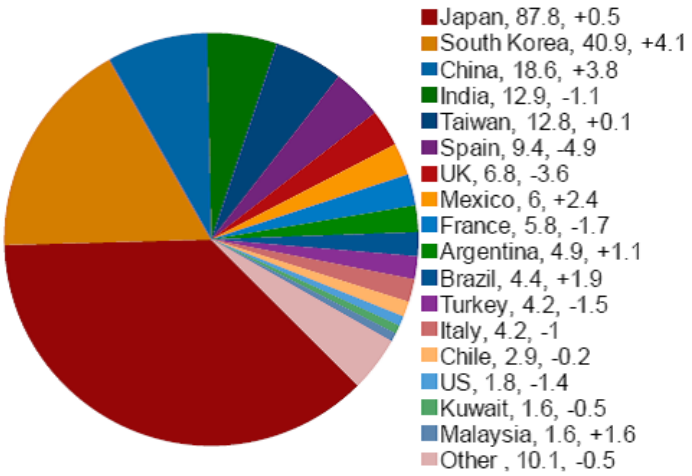
Sources: IHS, US DOE, IGU report 2014 p.9

WORLD'S TOP IMPORTERS AS PER 2013

The Asia-Pacific region was in 2013 the major LNG importer with approximately one hundred and seventy three metric tons (173 Mt), which accounts for 61% of total imports. It is quite obvious that developed economies like Japan and South Korea, as long as developing economies like China, India and Taiwan have turned to natural gas in order to satisfy their energy needs.

Japan – the world's single largest LNG market – saw a significant demand increase in 2011-12 as utilities expanded gas-fired power generation to make up for lost nuclear output after the Fukushima-Daiichi nuclear disaster. Nuclear generation, which previously accounted for 30% of power supply on average, made up just 3% of electricity supply by the second half of 2012 as plants were shutdown. In response, LNG imports grew by 24% from 2010 to 2012 (The Age of Gas & the Power of Networks).Europe is the second region, holding 14% of the global import shares, with U.K. and Spain being the greater importers.

Figure 1.4: 2013 LNG Imports by Country & Incremental Change Relative to 2012 (in MTPA)



Sources: IHS, US DOE, IGU report 2014 p. 9

NATURAL GAS RESERVES

The distribution of natural gas reserves is the main factor which determines the global flows of this energy cargo as long as the transportation modes to be used for its carriage. Natural gas reserves are often discovered near oil reserves deep beneath the Earth's surface. This is the reason, that very often the largest oil producing countries are simultaneously the largest LNG exporters. At the following table is presented the list of the countries with the largest natural gas reserves worldwide. Quite important share of the world's natural gas reserves percentage hold the Asia-Pacific region, establishing it as the main LNG market and as a major hub.

Table 1: Natural gas - proved reserves compares the stock of proved reserves of natural gas in cubic meters (cum)

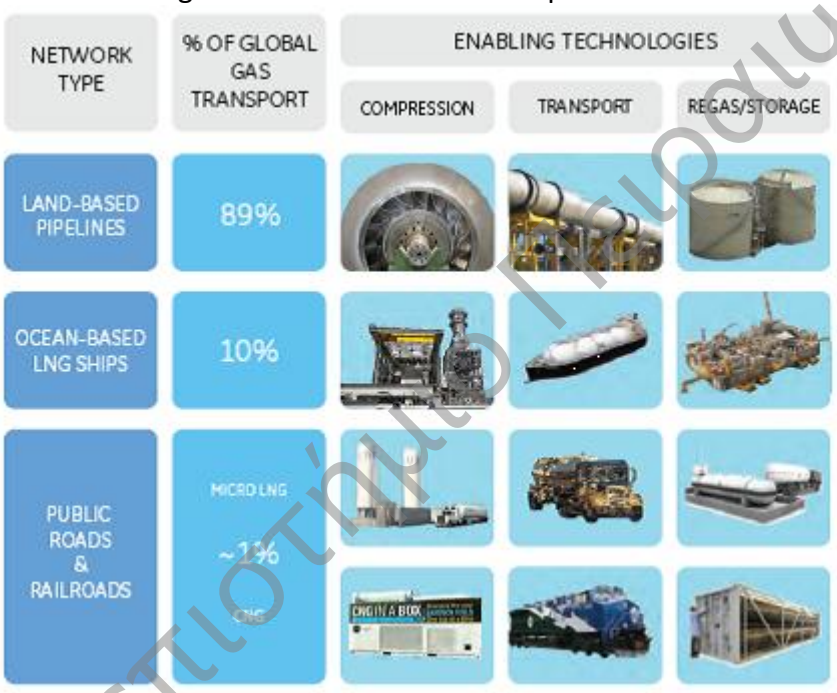
RANK	COUNTRY	(CU M)	DATE OF INFORMATION
1	Russia	47,800,000,000,000	1 January 2013 est.
2	Iran	33,610,000,000,000	1 January 2013 est.
3	Qatar	25,200,000,000,000	1 January 2013 est.
4	Turkmenistan	17,500,000,000,000	1 January 2013 est.
5	United States	9,459,000,000,000	1 January 2012 est.
6	Saudi Arabia	8,150,000,000,000	1 January 2013 est.
7	United Arab Emirates	6,089,000,000,000	1 January 2013 est.
8	Venezuela	5,524,000,000,000	1 January 2013 est.
9	Nigeria	5,153,000,000,000	1 January 2013 est.
10	Algeria	4,504,000,000,000	1 January 2013 est.
11	Iraq	3,158,000,000,000	1 January 2013 est.
12	China	3,100,000,000,000	1 January 2013 est.
13	Indonesia	3,069,000,000,000	1 January 2013 est.
14	Kazakhstan	2,407,000,000,000	1 January 2013 est.
15	Malaysia	2,350,000,000,000	1 January 2013 est.

Source: https://www.cia.gov/library/publications/the-world factbook/rankorder/2253rank.html (visited May 12, 2014)

THE DISTRIBUTION OF LNG

Transportation of natural gas depends on three modes of transport. 1)Pipelines, 2)LNG network and 3)piggy-backing on already existing road and rail infrastructure. By far the most significant mode today is pipelines, mostly land based, which transport approximately 89 percent of gas through a global network of over 1.4 million kilometers. Most of these pipelines, or about 70 percent, are regional lines that support gathering on the upstream and distribution within their domestic markets (The Age of Gas & the Power of Networks). More specifically, for large-scale transportation, the essential transportation mode is pipelines and LNG carriers.

Figure 1.5: Gas Network Transportation



Source: GE Global Strategy and Analytics 2013

The element that is essential for moving natural gas through pipelines is pressure. Pressure can be achievable through special compressors which are installed at specific intervals along the pipeline.

With compression, gas moves about 25 miles per hour (40 km per hour) through long distance pipelines. For example, gas takes about three days to travel the 2,000 mainline miles from the Eagle Ford shale in south Texas to New York City. Another example is the recently constructed Nordstream offshore pipeline extending 1,224 km from Vyborg, Russia to Greifswald, Germany. This pipeline uses special coatings to reduce friction, enabling the gas to traverse the Baltic Sea in little over a day. More than the speed, they move energy; the value of pipelines is that they have the ability to transport energy relative to other options (The Age of Gas & the Power of Networks a).

It is worth mentioning that pipelines transport approximately 89% of global natural gas quantity and their network is extended at a distance of 1.4 million kilometers.

The second mode is the LNG network, which constitutes 10 percent of global gas trade (The Age of Gas & the Power of Networks b). The sea trade of natural gas is based on the invention of the LNG carriers, which make possible the connection of the global markets and the areas of production with consumption areas. There are two kinds of such special purpose transport ships which are both double-hulled.

The first type, LNG carrier with Moss tanks, which are spherical tanks that are generally produced in aluminum or 9% nickel steel. The sphere is welded to a steel skirt that is connected to the hull of the ship and is then free to expand and contract as necessary. Insulation is fitted to the outside shell of the sphere but no secondary barrier is regarded as necessary across the upper part of the sphere. However, below the sphere, an aluminum drip tray, together with splash plates, provides secondary protection for the hull (www.liquefiedgascarrier.com a).

Such LNG carriers include four to five spherical tanks and the tank volumes are from 147.000m^3 to 270.000m^3. Their service speed is 19.5 to 22.0 knots.

Figure 1.6: Moss LNG Carrier

Source: http://www.liquefiedgascarrier.com/Liquefied-Natural-Gas-Carriers.html

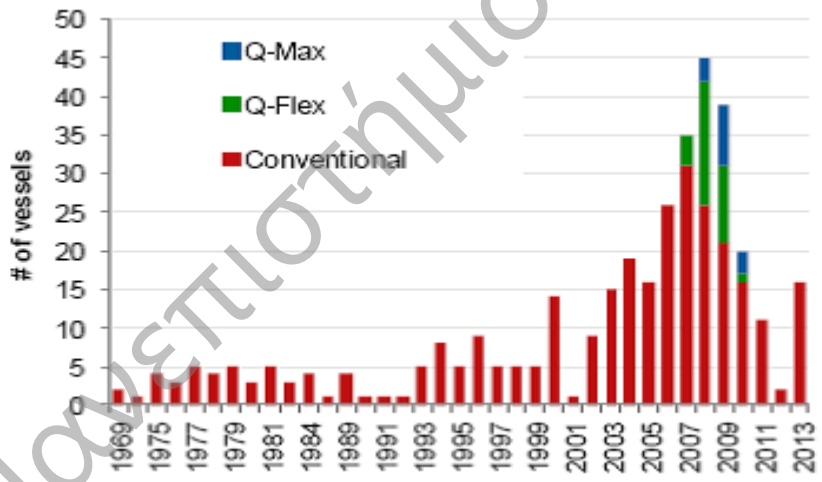
The second type of the LNG carriers is the membrane LNG carriers which include a liquefied gas tank design where the cargo is contained by a thin stainless steel or nickel alloy flexible membrane. There are two membrane systems in use. In both cases the insulation is fitted directly into the inner hull and the primary barrier consists of a thin metal membrane less than one millimeter thick. The Gaz Transport system uses two such membranes constructed of 'Invar' (36% nickel-iron low expansion alloy). One acts as the primary barrier and the other the secondary barrier and they are separated by plywood boxes of perlite insulation. Similar boxes are fitted between the secondary barrier and the inner hull. Loading is transmitted through the insulation to the ship structure. No centerline division is possible in this type of tank. The other system, developed by Technigaz, has a stainless steel membrane as the primary barrier while the secondary barrier is included in the insulation, which consists of load bearing balsa and mineral woods (www.liquefiedgascarrier.com b).

The conventional LNG carriers have a capacity ranging from 125,000 cm to 180,000 cm. Conversely, non-conventional vessels including the oversized Q-Flex and Q-Max types, offer the largest currently available capacities. Q flex capacities range from 210.000m^3 to 216.000m^3 , while Q-max capacity is approximately 266.000m^3. Currently, as per may 2014 there are 367 LNG carriers, 107 in the orderbook and 4 laid up.

Figure 1.7: Membrane LNG Carrier

Source: http://www.liquefiedgascarrier.com/Liquefied-Natural-Gas-Carriers.html

Figure 1.8: Global LNG Fleet by Year of Delivery



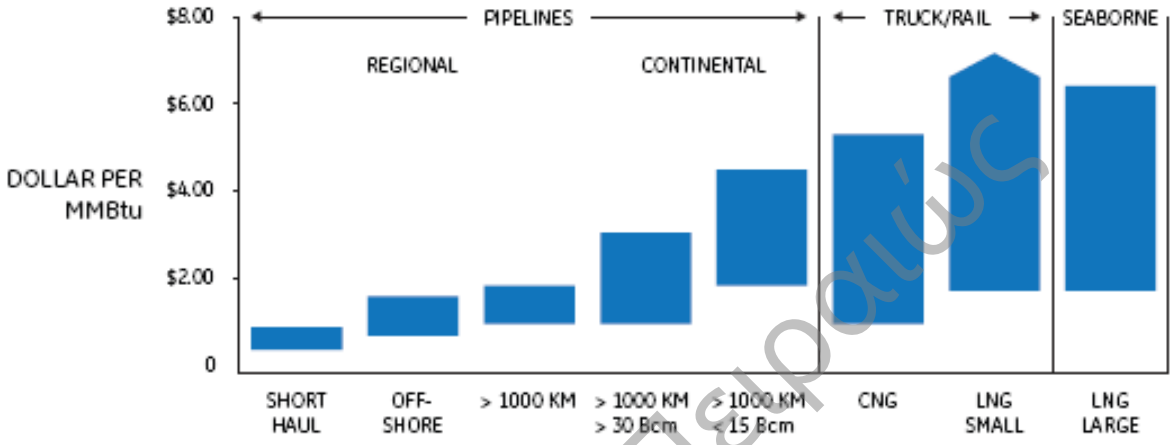
Source: IHS

The third transportation mode is the piggy-backing of the already existing infrastructure of road and rail.

This is possible through compression technologies like CNG and small-scale LNG. Compressing or liquefying gas reduces natural gas so it can be transported in steel tanks, tube trailers, or tanker trucks (The Age of Gas & the Power of Networks c). Through the third mode of transportation the natural gas is transferred to the consumers in order to satisfy domestic and industrial needs.

From the figure below it is very obvious that the seaborne trade of natural gas is by far the cheapest way to trade this energy cargo. Through seaborne trade economies of scale can be achieved and make LNG the most attractive solution for domestic and industrial use.

Figure 1.9: Cost of natural gas transport
NOTE: Small CNG and small LNG include local distribution and storage costs.



Source: The Age of Gas & the Power of Networks Peter C. Evans & Michael F. Farina, p.31

CNG Vs LNG

CNG Advantages:

- Containment system operates at ambient temperature, avoiding high capital expenditures required for liquefaction facilities
- Shorter project development timelines allowing for earlier production and greater returns on investment
- 60%-85% of the CNG value chain is moveable, whereas fixed facilities represent 60% of the cost of an LNG project
- CNG can be stored indefinitely without boil-off
- Only 5%-8% gas used during CNG transport process, compared to 15% for LNG

LNG Advantages

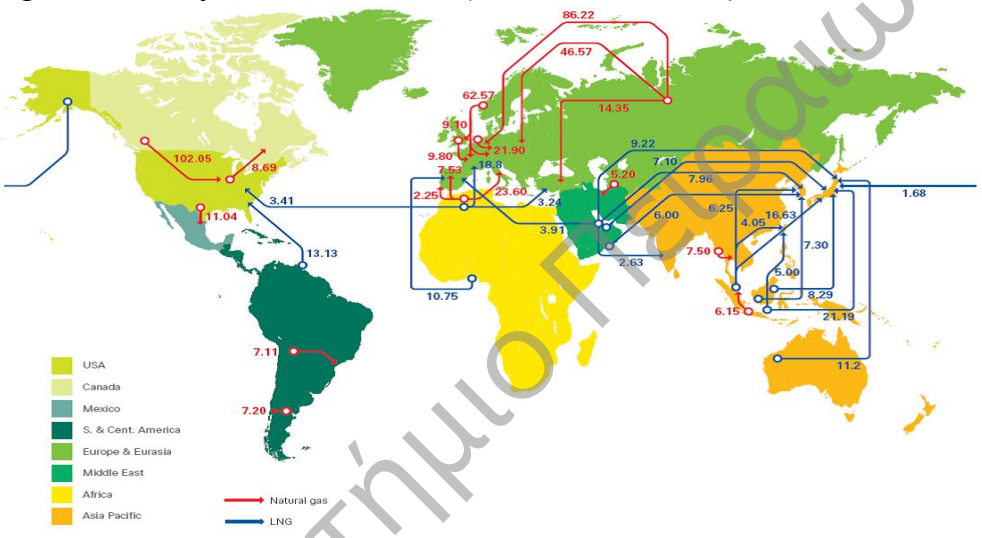
- Higher ship capacity allows LNG systems to use fewer ships over long distance gas delivery chains
- Industry familiarity / commercial inertia (www.neptunegas.ca)

THE GLOBAL FLOWS OF NATURAL GAS

The development in LNG supplies and marketing has been a crucial factor for incorporating global gas markets. A new emerging global market is being formed, with new ways of "doing business", where governments are not the decision makers, but private firms, who bear the extremely high initial cost of investment and take the risks, "call the shots". The natural gas industry is capital intensive and the return on investment ratio may last from fifteen to twenty years.

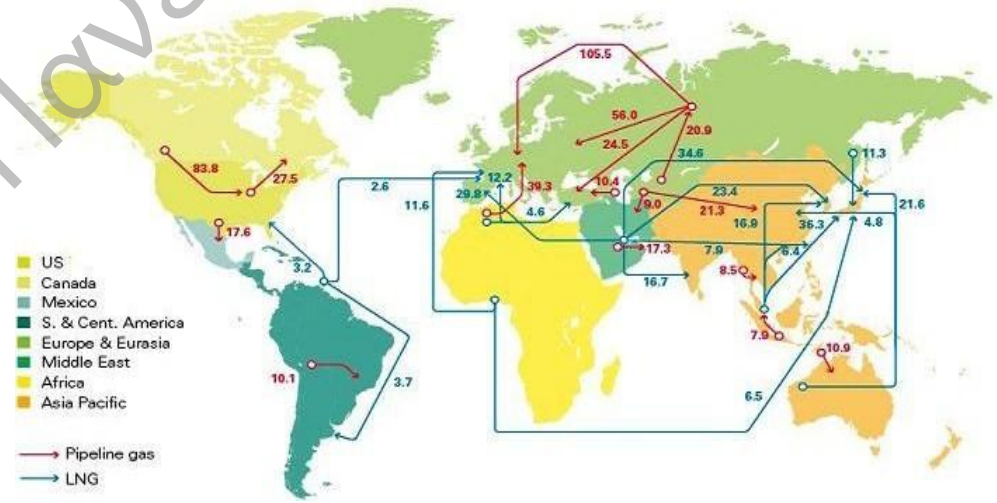
As aforementioned, the distribution of the natural gas reserves is the factor which determines the global flows of natural gas by pipelines, either by ship or by piggy-backing on the already existing road and rail infrastructure.

Figure 1.10: Major Gas Movements (billion cubic meters) end 0f 2004



Source: BP Statistical Review of World Energy June 2005

Figure 1.11: Major Gas Movements (billion cubic meters) end of 2012



Source: BP Statistical Review of World Energy June 2013 including data from Cedigaz, CISStat, GIIGNL, IHS CERA, Poten, Waterborne

From both figures it is remarkable that the LNG trade, in a period of eight years, has evolved rapidly. According to BP statistical reviews, in 2004 438,83 bcm of natural gas through pipelines and 167,74 bcm of LNG through LNG vessels, were transported worldwide. Respectively, in 2012 were transported 470,50 bcm of natural gas and 254,10 bcm of LNG. The LNG trade has boomed during this period integrating the three LNG importing markets. Russia, the major supplier of natural gas to Europe, will play a critical role to the formation of prices, as it operates a vast pipeline network.

In addition to gas deposits that it controls directly, Russia also exerts strong leverage on price and export quantities from the rich gas deposits of land-locked Turkmenistan (Gas Geopolitics A). The Middle East, including Iran, Qatar and Saudi Arabia, countries with large natural gas deposits, are geographically situated in a region which provides them the advantage of becoming a natural gas hub by connecting regional with global markets. The return on investment ratio has been delayed in the Middle East case due to the high initiative cost of the appropriate infrastructure.

Interestingly, Qatar's rise was contemplated and could have happened even a decade earlier if not for the distraction of political controversies with its neighbors and concern by major LNG users (notably Japan) about the risks of relying on gas tankers that had to traverse the dangerous waters of the Persian Gulf (Gas Geopolitics B).

Stranded gas fields, fields of gas that are not commercially usable due to economic or physical factors, will play an important role to the formation of global flows of natural gas.

The leading regions for stranded gas in gas fields are Russia with 33 %, South-east Asia and Oceania 17%, the Middle East 12%, and central Asia 12%. Overall, about 60 percent of the 2,612 TCF is in onshore stranded gas fields, and the remainder is offshore. However, 87% of the stranded gas of Southeast Asia and Oceania is offshore, and for Europe, 70% of the gas in stranded fields is offshore. Stranded gas volumes reflect the degree an area has been explored, the gas endowment, and the maturity of the area's transportation infrastructure (Emil D. Attanasi and Philip A. Freeman).

Producers from Russia are obliged to enter Russia's pipeline network in order to sell natural gas to European markets. The only central Asian producer who can sell natural gas to the western market is Azerbaijan. This is possible through Turkey.

Australia, Malaysia and Indonesia and Brunei, the Southeast Asian market, rely on LNG exports because their market is overseas. The LNG exports of these three countries terminals are headed in order to satisfy Japan's and China's energy demands.

Table2: Estimated cost of transporting LNG from LNG complex to destination regasification facility and market

		Yokohama, Japan		Shanghai, China	

LNG complex	Source location	Distance (nmi)	Transport cost ($/MMBtu)	Distance (nmi)	Transport cost ($/MMBtu)
Withnell Bay	Pilbara, Western Australia	3,850	1,65	3,565	1,54
Darwin	Darwin, Australia	3,164	1,40	2,879	1,29
Gladstone	Queensland, Australia	3,797	1,65	4,083	1,76
Bintulu	Sarawak, Malaysia	2,470	1,11	1,850	0,88
Blang Lancang	Arun, Sumatra, Indonesia	3,371	1,48	2,689	1,20
Tangguh	Irian Jaya, Indonesia	2,480	1,12	2,200	1,01
Donggi-Senoro	Sulawesi, Indonesia	2,460	1,13	2,120	1,00
Bontang	Kalimantan, Indonesia	2,570	1,14	2,220	1,00

Source: Role of Stranded Gas in Increasing Global Gas Supplies by Emil D. Attanasi and Philip A. Freeman, 2013, Appendix 3, p. 54

PIPELINE NETWORK AND NATURAL GAS FLOWS

Quite an important role in the formation of global flows of natural gas plays the global pipeline network, which interconnects regional markets. There are worldwide ten very long pipelines crossing sea, desserts, and plateaus, becoming the main energy artery, which provides economic growth and vitality through the supply of natural gas.

Table 3: The Ten Longest Natural Gas Pipelines

NAME	LENGTH	START	FINISH
1) West-East Pipeline ii	5,657 miles	Turkmenistan	Yangtze and Pearl River deltas
2) West-East Pipeline i	5,410 miles	Xinjiang, China	Shanghai
3) GASUN Pipeline (planned)	3,100 miles	Bolivia	Brazil
4)Yamal-Europe Pipeline	2,608 miles	Siberia	Germany
5) Trans-Saharan Pipeline (planned)	2,565 miles	Nigeria	Algeria
6) TransCanada Pipeline	2,005 miles	Alberta	Quebec
7) Rockies Express Pipeline (REX)	1,698 miles	Colorado	Ohio
8)Transcontinental Pipeline	1,671 miles	Texas	New York
9) Trans-Mediterranean Pipeline	1,610 miles	Algeria	Italy
10) Northern Border Pipeline	1,407 miles	Canada	Chicago
11) Nord Stream Pipeline	759 miles	Russia	Germany

Source: Forbes

The West-East Gas Pipeline 2 mainly carries natural gas from Turkmenistan and China's Xinjiang Uygur Autonomous Region to the Yangtze and Pearl River deltas, the country's two most developed regions. It was the first time China had started a project to pipe natural gas from a foreign country. Construction of the 9,102-kilometer pipeline, which consists of a main line and eight sub-lines, cost 142.2 billion yuan (about US$20 billion). With a designed gas transmission capacity of 30 billion cubic meters annually, the pipeline would traverse 12 provinces and autonomous regions before reaching Shanghai and the southern Guangdong Province (China Starts Work on $20B Pipeline for Turkmen Gas)..

The West-East Gas Pipeline 1 starts at Lunnan of Xinjiang in the west and ends at Baihe town in Shanghai in the east, crossing nine provinces of autonomous regions and one municipality, i.e. Xinjiang, Gansu, Ninxgia, Shanxi, Henan, Anhui, Jiangsu, Zhejiang, and Shanghai, with a total length of 4,000Km and the trunk pipeline of 1,016mm in diameter. The design annual throughput is 12 bcm. The West-East Gas Pipeline has been so far the longest gas transmission pipeline in

China, which is the largest in terms of the diameter and the transmission volume and involves the most advanced technology and the most complicated construction conditions (Xie Geguo).

China National Petroleum Corp (CNPC) started on Tuesday construction of a third cross-country gas pipeline, the Xinhua news agency said, a project estimated to cost 125 billion Yuan ($19.93 billion) and aimed at boosting gas imports from central Asia. The third West-East pipeline, which will span more than 5,000 km starting from the northwestern border in Xinjiang to Fujian province in the southeast, will have a capacity to transport 30 bcm per year. Construction of the pipeline, which will be linked to the central Asia pipeline, is due to be completed in around 2015 using gas pumped in from central Asia (China starts work on 3rd West-East gas pipeline).

The GASUN pipeline, which will be connecting Bolivia to Brazil, should be completed in 2026. The first stretch of GASUN will be a branch of the existing Brazil-Bolivia pipeline.

The transnational Yamal – Europe gas pipeline runs across four countries: Russia, Belarus, Poland and Germany. The new export corridor increased flexibility and reliability of Russian gas supply to Western Europe. The European Union qualified the Yamal – Europe as the top-priority investment project implemented as part of the Trans-European Network (TEN). The gas pipeline construction started in 1994 and in 2006 the Yamal – Europe gas pipeline reached its design capacity of 32.9 bcm after the last compressor station commissioning. The number of compressor stations at the gas pipeline – 14, the pipe diameter – 1,420 millimeters, the total length – over 2,000 kilometers (www.gazprom.com) .

The Nigeria – Algeria Pipeline is also referred to as the Trans – Saharan gas pipeline (TSGP) is a huge project. This pipeline with length of approximately 2,565 miles is going to connect Nigeria to Algeria. This energy artery from Nigeria's Warri to Algeria's Hassi R'Mel, which is expected to reach a capacity of 30 bcm per annum, is estimated to be completed in 2015.

The TransCanada pipeline is a main gas artery from Canada's Alberta to Quebec with a length of 2,005 miles, which is going to be converted to an oil pipeline.

The Rockies Express Pipeline (REX) is one of the largest pipelines in the U.S.A. The 1,698 miles pipeline stretches from the Rocky Mountains of Colorado to Eastern Ohio. Its operation started in 2009 and its capacity reaches 1,8 billion cubic feet per day. The Rockies Express Pipeline is a joint venture of Tallgrass Development (through a subsidiary, Tallgrass Development owns a 50 percent interest in and operates the pipeline), Sempra US Gas & Power and Phillips 66. Long-term, binding, firm commitments have been secured for virtually all of the pipeline's capacity.

The transcontinental gas pipeline is an energy corridor stretching from Corpus Christi, Texas to New York. It is the major gas provider to the northeastern and southeastern states. The Transcontinental pipeline is the nation's largest-volume interstate natural gas pipeline system, with a capacity of 9.8 billion cubic feet per day and a length of 1,800 miles. It is owned by Williams Partners.

The Trans-Mediterranean natural gas pipeline was built in 1983 in order to transfer natural gas from Algeria via Tunisia and Sicily to Italy. Beginning from Algeria, the Trans-Mediterranean gas pipeline runs 550 Km to Tunisian border. From Tunisia the pipeline passes 370 Km to El Haouaria in the Cap Bon province and then

crosses the 155km-wide Sicilian section. Its capacity is estimated to be 33.5 billion cubic meters per annum.

The Algerian section is operated by Sonatrach, the Algerian State Authority. The Tunisian section is owned and controlled by Sotugat and Sergaz respectively. The channel of Sicily is controlled by Trans-Mediterranean Pipeline Company (TMPC), a joint venture of Eni and Sonatrach. Snam Rete Gas, a subsidiary of Eni, operates the Italian section (www.hydrocarbons-technology.com).

Northern Border Pipeline is a major natural gas transportation system that links the Midwestern U.S. with reserves in the Western Canadian Sedimentary Basin (www.northernborder.com). It is a 1,407 miles pipeline that transfers natural gas through Montana, North Dakota, South Dakota, Minnesota, and Iowa to Chicago, while its design capacity is 2,400 million cubic feet per day. The Northern Border Pipeline Company is a partnership owned 50% by TC Pipelines and 50 percent by ONEOK Partners.

The Nord Stream twin submersible pipeline is the longest of its kind in the world with a length of 759 miles and a capacity 55 billion cubic meters per annum serving the Exclusive Economic Zones of Russia, Finland, Sweden, Denmark and Germany, as well as the territorial waters of Russia, Denmark, and Germany. It begins from Vyborg, Russia to Lubmin near Greifswald, Germany.

CONCLUSIONS

From these eleven longest pipelines globally, four of them serve the North American market, a mature market in which natural gas as an energy fuel has been being used for over thirty years and the main transportation mode is the pipeline network. More specifically U.S.A. has, according to EIA, more than 210 natural gas pipeline systems and 305,000 miles of interstate and intrastate transmission pipelines. Additionally, there are 49 locations where natural gas can be imported/exported, 8 LNG import facilities and 100 LNG peaking facilities. U.S.A. imports natural gas from Canada and some limited quantities of LNG from the global market, while there is a bilateral gas trade between U.S.A. and Mexico.

However the rapid turnaround in US gas production has left many of these LNG receiving facilities redundant and the owners are now looking to convert them into export facilities to exploit the current arbitrage opportunities among US, Asian and European gas prices (James Henderson).

In contrast to the North American market, the Asian market is extensively fragmented, including smaller gas markets that are not all connected via pipelines. As a result, the flows of natural gas will be through LNG to regasification terminals of Japan, China, S. Korea and India. LNG exports from the Middle East target the European market too.

LNG exports from Qatar targeted the natural gas market in the USA. Over time, it has successfully managed to divert some of its LNG volumes to other markets. In 2008, Qatargas 4 opened up new markets for Qatari LNG through long-term sales to China and Dubai (www.shell.com). Japan and China as well import Qatari LNG. Oman, located to the Gulf of Oman has access to the Arabian Sea and the Persian Gulf, the most energy important corridors, almost all of the country's

exports target Japan and China. Despite the fact that Oman is not a major importer of natural gas, every year it imports 71 bcf from Qatar through the Dolphin Pipeline, and its future domestic demand for natural gas demand may limit the country's exports. Yemen, another big LNG exporter, exported in 2011 90% of its total dry natural gas production which stands for 309 bcf. According to IHS Global Insight, Yemen LNG provided approximately 3 percent of global LNG volumes as of early 2013. This country is strategically located at the crossroads of international shipping lines and has access to Far-East, Middle-east, Europe and American markets. Via LNG exports U.A.E. as well sell their natural gas to China, Japan, India and finally through Suez to Europe.

An African major LNG exporter is Nigeria, where the Trans-Saharan pipeline is planned to be installed and to provide Algeria with Natural gas. Nigeria's location is strategic. Nigerian LNG exports can reach all three major LNG markets, North-American, European and East-Asian. Bonny and Brass LNG liquefaction terminals provide Japan and West Europe with LNG.

The South-East Asian producers, Australia, Malaysia, Indonesia and Brunei supply Japan and China with LNG. Australia includes three LNG liquefaction plants, Karratha, Pluto and Darwin LNG plant, Malaysia one, Tanjung Kidurong, Indonesia three, Bontang, Tangguh and Arun and finally Brunei with one, Lumut liquefaction plant.

Quite smaller but not unremarkable capacities of LNG exports Trinidad via Atlantic LNG plant to U.S.A., France and Argentina.

The growth in natural gas trade depends on many factors. Demand for an energy cargo is related to the world economic growth. The last recession which came into the limelight had severe impacts on world trade and freight rates. The regulatory framework has become more flexible the past decade, giving the opportunity to gas related companies and traders to formulate new terms of buying and selling natural gas in an integrated global market. The governments could accelerate the consolidation of natural gas as a well-established fuel by providing economic incentives for reduction of carbon dioxide emissions.

CRUDE OIL MARKET AND ITS GOBAL FLOWS

CHARACTERISTICS OF CRUDE OIL

Crude oil, commonly known as petroleum or “black gold”, is a yellow-to-black solid liquid found within the Earth’s underground areas called reservoirs. Crude oil is a mixture of hydrocarbons, organic compounds and metals. The main component of crude oil is hydrocarbons which make up 50% to 90% of petroleum, depending on the type of crude oil and on the way of its extraction. As far as the organic compounds that crude oil contains, nitrogen, oxygen and sulfur usually make up 6% to 10% and metals like vanadium, nickel, iron and copper account for less than 1% of its total composition.

Crude oil is created through the heating and compression of organic materials over a long period of time (www.oilprice.com).

Oil extraction is achieved through drilling. There are several ways of drilling, horizontal, multilateral, extended and complex drilling.

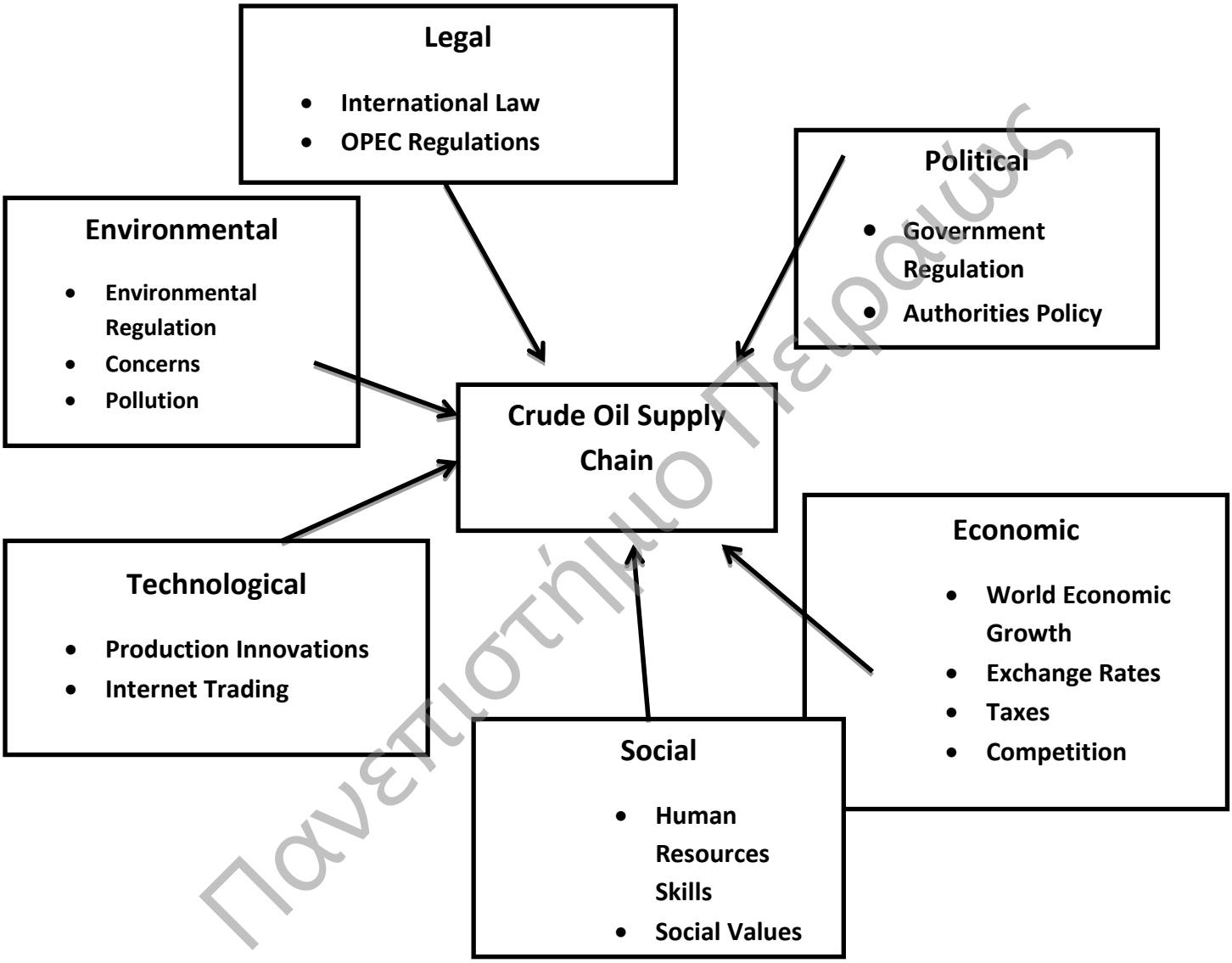
Horizontal drilling starts with a vertical well that turns horizontal within the reservoir rock in order to expose more open hole to the oil. These horizontal "legs" can be over a mile long; the longer the exposure length, the more oil and natural gas is drained and the faster it can flow. More oil can be produced with fewer wells and less surface disturbance. However, the technology only can be employed in certain locations. Sometimes oil reserves are located in separate layers underground. Multilateral drilling allows producers to branch out from the main well to tap reserves at different depths. This dramatically increases production from a single well and reduces the number of wells drilled on the surface. Extended Reach Drilling allows producers to reach deposits that are great distances away from the drilling rig. This can help producers tap oil deposits under surface areas where a vertical well cannot be drilled, such as under developed or environmentally sensitive areas. Wells can now reach out over 5 miles from the surface location. Offshore, the use of extended reach drilling allows producers to reach accumulations far from offshore platforms, minimizing the number of platforms needed to produce all the oil. Onshore, dozens of wells can be drilled from a single location, reducing surface impacts. Complex Path Drilling creates well paths with have multiple twists and turns to try to hit multiple accumulations from a single well location. Using this technology can be more cost effective and produce less waste and surface impacts than drilling multiple wells (www.api.org).

THE CRUDE OIL SUPPLY CHAIN

The crude oil supply chain includes upstream, midstream and downstream activities. Upstream activities refer to prospecting, accessing and drilling, midstream activities refer to developing and producing, transporting, processing and refining and the downstream activities refer to marketing and sales. The petroleum industry is affected by several factors due to the volatility of crude oil’s price, which is fixed by the factors of supply and demand. A PESTEL analysis (analysis of Political,

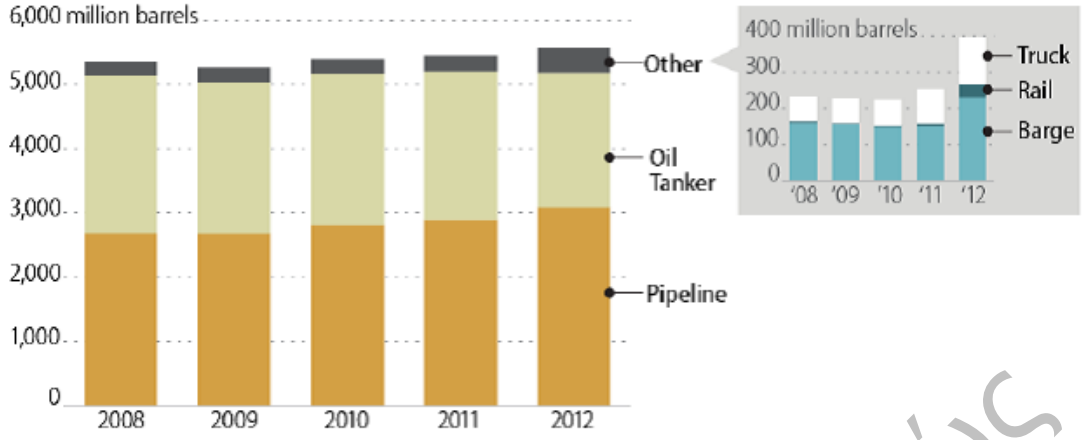
Economic, Social, Technological, Environmental and Legal framework) to the upstream crude oil supply chain follows in order to point out the external factors that affect all the operations involved.

Figure 2.1: PESTEL analysis to the upstream crude oil supply chain



Several transporting methods are used during the crude oil transfer such as oil tankers and barges for sea transfer, pipelines and railways. Each mode has its own purpose. Large tankers are used for oil conveyance through great distances due to the economies of scale that they provide. Through this transporting mode the integration of all big crude oil markets is feasible. Smaller tankers are usually met in more regional markets, while barges that carry crude oil are used for very short distances. As far as pipelines, they connect interregional markets and so do railways by transferring oil from producing regions to market hubs even though rail is a relatively high-cost method of oil conveyance.

Figure 2.2: U.S. Refinery Receipts of Crude Oil by Mode of Transportation



Source: Prepared by CRS; data from EIA, Refinery Capacity Report, Table 9, June 2013

Notes: Some shipments may involve multiple modes, such as rail to barge. This figure indicates only the mode used for the last leg of such shipments.

There are several types of crude oil with different density (light to heavy) and sulfur content (sweet to sour) as well. Crude oil's density is classified by the American Petroleum Institute (API). API gravity is defined by crude oil's density at a temperature of 15.6^0C. The higher the API gravity, the lighter the crude oil is. Light crude oil has API gravity of 38 degrees or more, medium crude oil has API gravity between 22 and 38 degrees, while heavy crude oil has API gravity of 22 degrees or less. Sweet crude oil contains less than 0.5% sulfur and sour crude oil contains more than 0.5% sulfur. Light sweet crude oil is more expensive than heavy sour crude oil, which requires less processing. The different types of crude oil are: Brent Blend, Russian Export Blend, and West Texas Intermediate.

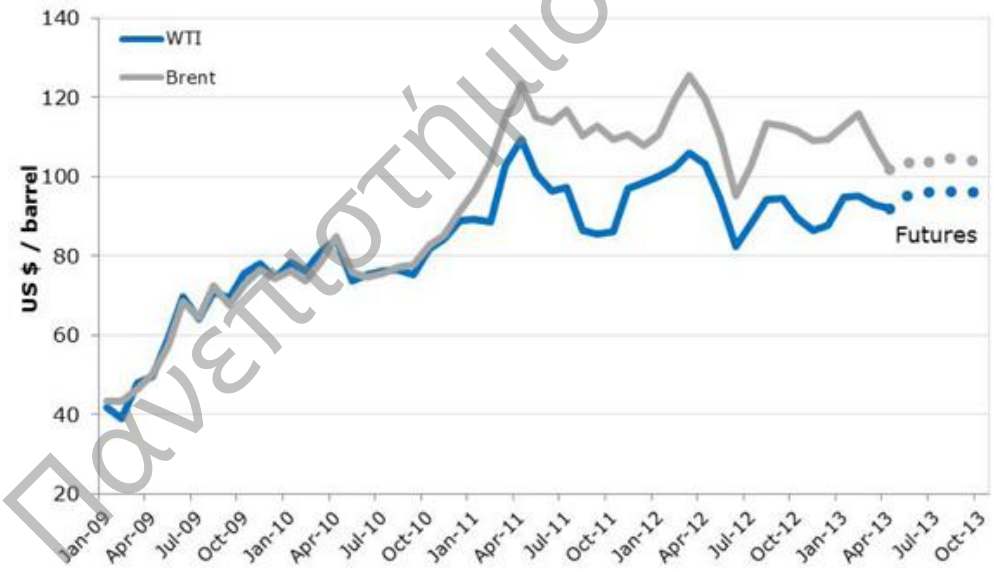
Brent Blend is light, sweet North Sea crude with an API gravity of approximately 38 and a sulfur content of approximately 0.4%. Most Brent Blend is refined in Northwestern Europe, but significant volumes are also shipped to the US and Mediterranean countries. Brent Blend is used for pricing around two-thirds of the crude traded internationally. Rolling price assessments are based on physical Brent-Forties-Oseberg crude oil cargoes loading not less than 10 days ahead and loaded free on board at the named port of shipment ('Brent Dated). Russian Export Blend, the Russian benchmark crude, is a mixture of several crude grades used domestically or sent for export. Russian Export Blend is a medium, sour crude oil with an API gravity of approximately 32 and a sulfur content of approximately 1.2%. Its spot price is reported at Augusta, Italy, and Rotterdam, the Netherlands, which act as the two primary delivery points. West Texas Intermediate, the US benchmark crude oil, is a light, sweet crude oil with an API gravity of approximately 40 and a sulfur content of approximately 0.3%. The spot price of West Texas Intermediate is reported at Cushing, Oklahoma (www.nesteoil.com). Ultimately the Dubai Crude, which originates from Dubai, has a light density, 31 degrees of API gravity and contains 2% sulfur.

AN OVERVIEW OF THE CRUDE OIL MARKET

The crude oil market is an extremely volatile market and oil prices are affected by many exogenous factors. The world economic growth and trade which are directly connected to oil prices determine the demand of oil. Another crucial factor is the OPEC production which accounts for 40% of world production and its exports which account for 60% of world exports to international markets. Additionally the global oil inventories which are responsible for balance between supply and demand are another critical factor determining the oil prices. Financial markets play an important role as well. Oil traders not only sell oil by physical distribution, but they also trade contracts known as "futures", for crude oil's future delivery at an already determined price.

A protracted period of steep decline in European oil demand eased back earlier in 2013 and in some instances even reversed as the euro zone emerged from the claws of recession. From the 12-month period of 2Q12-1Q13 to 3Q13, the most recent quarter for which complete data are available, average European demand growth jumped by about 0.7 mb/d, swinging from an average decline rate of 530 kb/d y-o-y to net growth of roughly 175 kb/d (International Energy Agency A).

Figure 2.3: West Texas Intermediate and Brent prices



Source: http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgytlk/tlksmmr2013/crdlgsln-eng.html

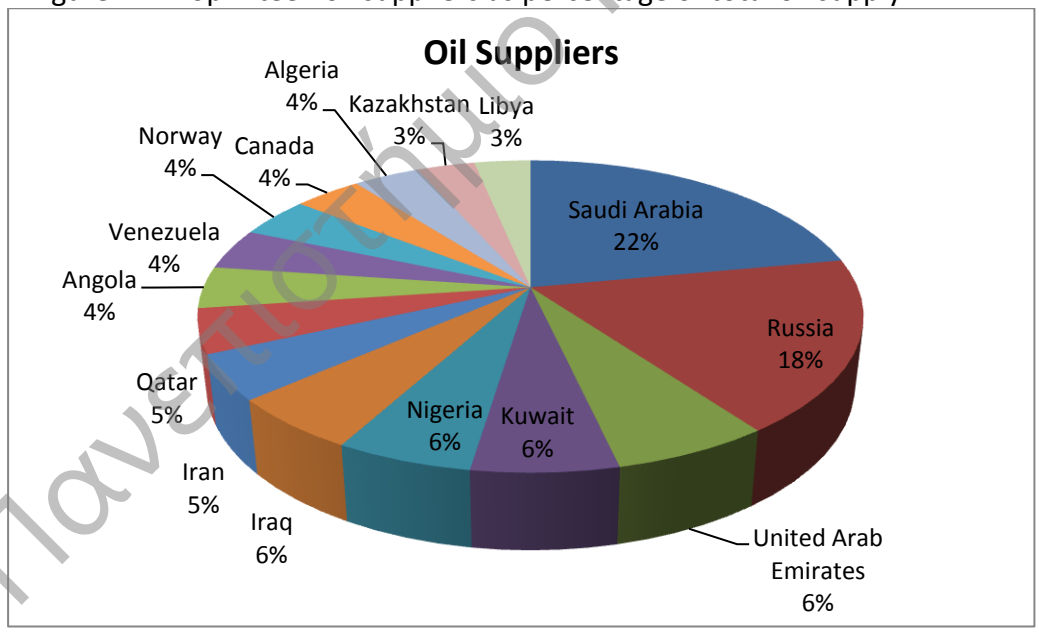
An increase in U.S. oil demand of approximately 110 kb/d has been noticed, while global oil demand seems to have increased approximately 1.5 mb/d in 3Q13, a number which stands for 0.4 mb/d above the average growth rate of 2012. China's average demand as per October 2013 was 10 mb/d included not only crude oil, but also net product imports, a number which equates to an increase of a 2.4% on the year. On the other hand, Japan faced continued drops from energy sector in oil demand while electric utilities turn to coal as a source of energy.

Rapid gains in industrial oil use since April have raised the estimate of Russian demand for 2013 to around 3.4 mb/d, up 120 kb/d (or 3.7%) y-o-y and 15 kb/d above last month's projection (International Agency Energy B). Brazilian demand continued to strengthen in October 2013 with average imports of approximately 3.3 mb/d.

WORLD'S TOP CRUDE OIL SUPPLIERS AS PER 2012

Fifteen countries were the major oil suppliers as per 2012. Saudi Arabia with 8,865 kb/d, Russia with 7,201 kb/d, U.A.E. with 2,595 kb/d, Kuwait with 2,414 kb/d, Nigeria with 2,254 kb/d, Iraq with 2,235 kb/d, Iran with 1,880 kb/d, Qatar with 1,843 kb/d, Angola with 1,738 kb/d, Venezuela with 1,712 kb/d, Norway with 1,680 kb/d, Canada with 1,576 kb/d, Algeria with 1,547 kb/d, Kazakhstan with 1,355 kb/d and finally Libya with 1,313 kb/d (www.eia.gov A). From the data above it is obvious that the Asian market is the exports leader while an important share of global oil supply holds Africa with four supplying countries, Nigeria, Angola, Algeria and Libya. Venezuela represents the South American market, Norway the European market and Canada the North American market.

Figure 2.4: Top fifteen oil suppliers as percentage of total oil supply



Data from http://www.eia.gov/countries/index.cfm?topL=exp

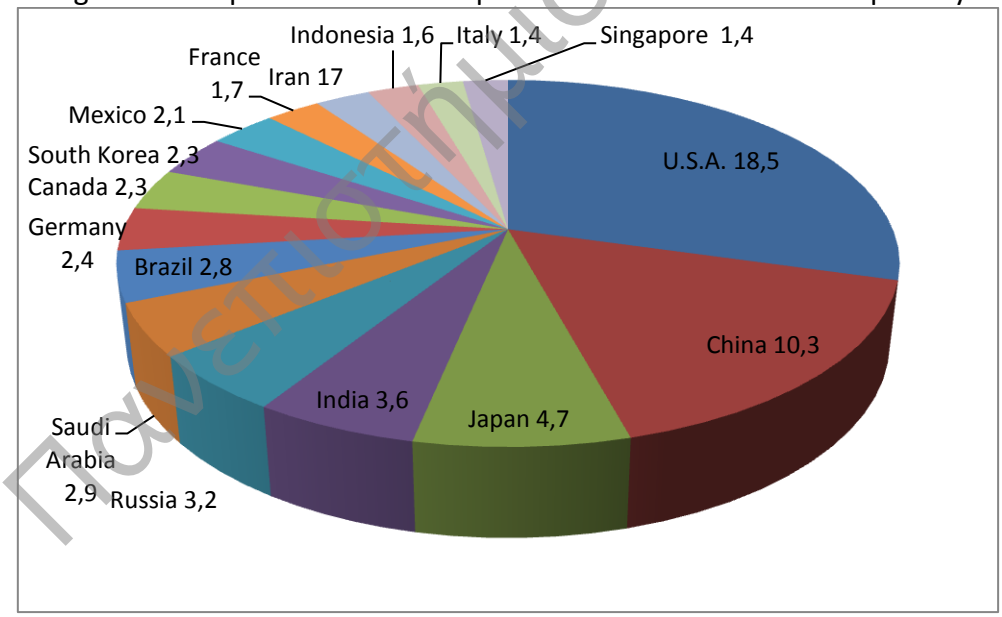
WORLD'S TOP OIL CONSUMERS AS PER 2012

U.S.A. was in 2012 the biggest crude oil consumer with 18.5 mb/d. U.S.A. is a developed country with serious energy needs because of the many industrial clusters that includes. U.S.A. mature market includes many petroleum exporting companies. Even though U.S.A. have many oil refineries and produce great quantities of

petroleum they need to import crude oil. China was the second biggest crude oil importer with 10.3 mb/d. China is the world's most populous country and a very fast growing economy and its national oil companies are the main players to the crude oil supply chain. China imports crude oil from many different sources due to the increasing oil demand and the geopolitical uncertainties. Japan follows with a daily consumption of 4.7 mb/d. Japan has very few oil resources and that is the reason why this country relies on imports of crude oil. India was the fourth crude oil consumer with a rate of 3.6 mb/d. India is a considered a developing country whose crude oil imports rely mostly on Middle East. Russia's daily crude oil consumption accounts for 3.2 mb/d. Russia is also a big crude oil exporter while Saudi Arabia's daily consumption accounts for 2.9 mb/d. Brazil's rank as far as the oil consumption is 7 with a daily consumption of 2.8 mb/d, while it is the eighth largest energy consumer worldwide. 90% of the country's production is offshore and is mainly heavy grades.

Canada's unconventional oil sands are a significant contributor to the recent and expected growth in the world's liquid fuel supply and comprise the vast majority of the country's proven oil reserves, which rank third globally (www.eia.gov B). Germany is the ninth largest oil consumer worldwide and the second in the Eurasia area. Germany imports crude oil through four pipelines and four oil terminals through sea.

Figure 2.5: Top oil consumers as per 2012 in millions of barrels per day



Source: data from http://www.eia.gov/countries/index.cfm?view=consumption

South Korea is the tenth largest crude oil consumer with a daily consumption of 2.3 mb/d. This country has insufficient energy resources so it relies on imports to satisfy its energy needs, although it has a developed oil refining sector.

CRUDE OIL RESERVES

As aforementioned crude oil is usually found within the Earth's underground areas known as reservoirs or reserves. Crude oil can also be found in oil sands.

Oil sand is a naturally occurring mixture of sand, clay or other minerals, water and bitumen, which is a heavy and extremely viscous oil that must be treated before it can be used by refineries to produce usable fuels (www.energy.alberta.ca).

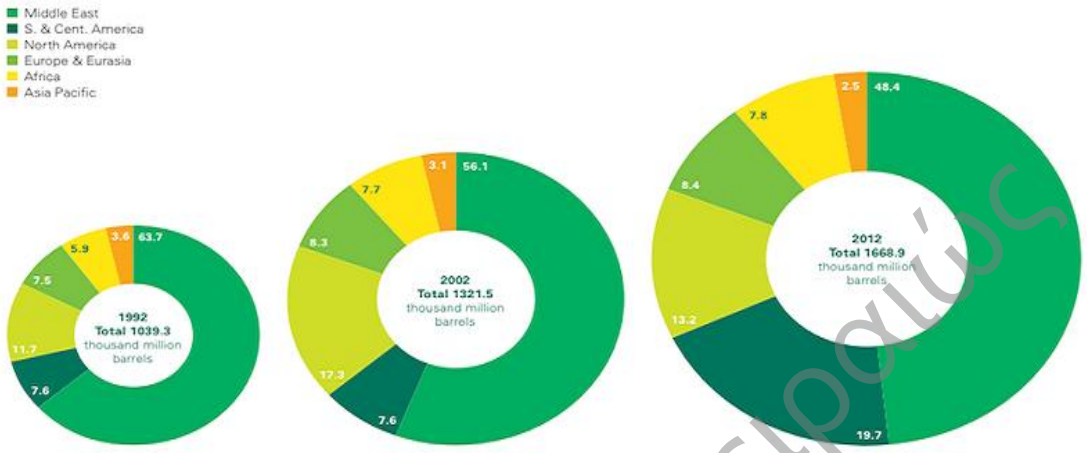
It is obvious that the distribution of these reserves and oil sands, which is uneven, will be the main factor which will be critical to the formation of the crude oil global flows. Crude oil is transported from the producing areas to consuming areas in order the latter to meet their energy demands. The Middle East has been since always the main crude oil producing area. More specifically Saudi Arabia has approximately 20% the world's proven oil reserves, maintains the world's largest oil production capacity and simultaneously is the largest producer and exporter of crude oil distillates. Only eight fields in Saudi Arabia contain half of its proven oil reserves. Saudi Arabia's oil reserves were estimated to be 267 mb as per 2012. Iran is a country where five giant fields contain more than half of its proved oil reserves. As per 2012 Iran's proved oil reserves accounted for 151.2 mb. Iran is also an OPEC member and its exports dropped in 2012 to 1.5mb/d as the U.S.A and the E.U. tightened sanctions which affected the country's oil exports. Iraq is ranked fifth as far as its proven crude oil reserves, which as per 2012 accounted for 143.1mb and at the end of the same year Iraq passed Iran as the second largest oil producer in OPEC. Due to the country's political instability and infrastructure limitations and despite the large proven oil reserves, not any increases in oil production have been met. Kuwait's proven oil reserves as per 2012 were estimated to be 104mb, holding the world's sixth largest oil reserves. U.A.E. an OPEC member, held as proven oil reserves in 2012 97.8 mb and has one of the highest rates of petroleum consumption per capita globally while another OPEC member's, Qatar's, proven oil reserves accounted as per 2012 for 25.4 mb. South and Central America keep an important share of proven oil reserves. Venezuela contains some of the world's largest oil reserves and is one of the main suppliers to the U.S.A. Venezuela's proven oil reserves were estimated in 2012 to be 211.2 mb, Brazil's 14 mb and Mexico's 10.4 mb. North America is a region with great importance in oil production. Its most important representative, Canada, is a major oil producing country with reserves, as per 2012 173.6 mb.

Canada's unconventional oil sands are a significant contributor to the recent and expected growth in the world's liquid fuel supply and comprise the vast majority of the country's proven oil reserves, which rank third globally (www.eia.gov C).

To the same region, proven oil reserves in U.S.A. accounted as per 2012 for 26.5 mb. Europe and Eurasia regions contain large proven oil reserves and more specifically Russia. Russia's proven oil reserves were estimated to be in 2012 60 mb. Russia's largest share of oil exports is transported via the country's pipeline network. The African continent is reach in oil too. Libya, Africa's holder of largest reserves and an OPEC member, was estimated to have in 2012 47.1 mb. Libya's exports oil to Europe, while Italy is the main recipient. Nigeria is Africa's second holder of largest reserves and its proven oil reserves accounted in 2012 for 37.2 mb, but the instability in the Niger Delta has led many companies to declare force majeure in oil shipments. Algeria as per 2012 held large oil reserves, which accounted for 12.2 mb.

and all of them are held onshore. Asia Pacific's main representative is China, which as per 2012 held 20.4 mb in its proven oil reserves.

Figure 2.6: Distribution of proved reserves in 1992, 2002 and 2012 Percentage



Source: BP Statistical Review of World Energy June 2013, p.7

THE DISTRIBUTION SYSTEM OF CRUDE OIL

Due to the uneven distribution of oil reserves, its transportation is obligatory from production to consuming areas. Through the transportation of crude oil, the local and national markets are integrated into one global oil market. Various modes of transportation are used in oil trading. Each one has its own characteristics which define its role. The transportation modes used in oil trade are the following: tanker vessels and barges for sea transportation, pipelines for sea and inland transportation and finally rail and specialized trucks for inland transportation, the last usually for oil products and for the last customer market.

Tankers are merchant vessels which are designed to carry liquid or gas cargo in bulk form. The size of these vessels varies from type to type and it is related to the geographical market in which the vessel is employed. Tankers of less than 100.000 dwt are often referred as "clean" tankers. The term "clean" means that the vessel carries refined petroleum products such as kerosene, gasoline, jet fuels or chemicals. The rest of them, the "dirty" tankers carry heavy fuel oil or crude oil. Tankers is a relatively cost-effective mode of transportation due to the economies of scale that are developed through the transportation of great quantities oil and reduce the unit cost, in that case the barrel cost.

- Coastal is a vessel with a dwt from 3.001 to 10.000 and is usually employed in coastal waters with shallow drafts carrying kerosene, heating oil, jet fuels and chemicals.
- Small is a vessel with a dwt from 10.001 to 19.000, is the next size tanker and is usually employed in coastal waters with shallow drafts carrying kerosene, heating oil, jet fuels and chemicals.
- Handy or Handysize is a vessel with a dwt from 19.001 to 25.000 or from 10.000 to 34.999, employed more in local markets such as the Mediterranean.
- Medium or Handymax is a vessel with a dwt from 25.001 to 45.000 or from 35.000 to 49.999 employed more in short voyages.
- Long/Long Rage One (LRI) is a vessel with a dwt from 45.001 to 70.000 or from 45.000 to 79.999, employed in long voyages.
- Large/Long Rage Two (LRII) is a vessel with a dwt from 70.001 to 100.000+ or from 80.000 to 159.999, employed in long voyages.

The exclusively crude oil carriers are categorized as following:

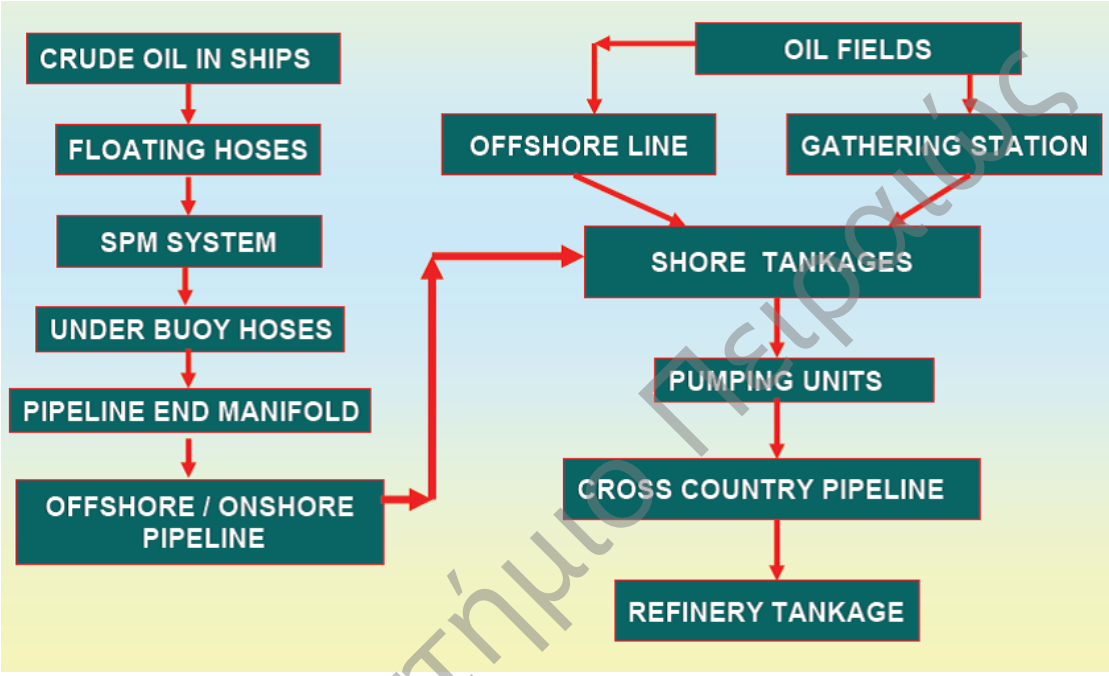
- Panamax is a vessel with a dwt from 50.001 to 80.000 and an approximate beam limitation of 32.2 m. This is the maximum vessel size that can pass through the locks of the Panama Canal.
- Aframax is a vessel with a dwt from 80.001 to 119.999 and is the largest crude oil carrier in the AFRA (Average Freight Rate Assessment) tanker rate system.
- Suezmax is a vessel with a dwt from 120.000 to 150.000 and is the maximum vessel size that can pass through the Suez Canal in Egypt.
- Very Large Crude Carrier (VLCC) is a vessel with a dwt from 150.00 to 320.000. This type is usually employed to carry crude oil from the Gulf, West Coast of Africa, North Sea to the U.S.A, Europe, Asia and when empty is possible to pass through the Suez Canal.
- Ultra Large Crude Carrier (ULCC) is a vessel with a dwt from 320.000 to 564.763 (the Jahre Viking) employed in very long voyages and usually require custom built terminals for loading and unloading operations.

Tank barges are another mode of oil transportation. A tank barge is a storage vessel used to carry bulk liquids and is either self-propelled or tied by a tug. Tank barges can vary in size and are categorized by the number of barrels of product that can carry. They are employed in inland waterways, connecting regional markets and also on coastal movements, a trend which is currently seen along the Gulf of Mexico Coast, from Texas' Corpus Christi to other refineries till Louisiana coast, an area known as "refinery row". On the West Coast, tank barges transport crude oil extracted from Bakken, North Dakota, via Anacortes oil terminal, Washington, to San Francisco and Los Angeles, California.

The economics are compelling. A typical 30,000-barrel tank barge can carry the equivalent of 45 rail tank cars at about one-third the cost. Compared to a pipeline, barges are cheaper by 20-35 percent, depending on the route (www.maritime-executive.com).

Crude oil is widely transported through pipelines, the most economically feasible mode of oil transportation from short haul to middle scale distances. Pipelines are energy lifelines connecting interregional markets, transferring crude oil from point of receipt to point of delivery with the help of pressure. Pressure is achievable through the contribution of special compressors which are installed at specific intervals along the pipeline. Economies of scale are also achievable via the use of pipelines, a lower energy intensive mode of transportation which is simultaneously environmental friendly and can handle multiple products.

Figure 2.7: Pipelines system



Source: Transportation of Oil and Gas through Pipelines p.13 by V.C. Sati

Railways play an important role in the transportation of crude oil to refinery stations and their use is widely prevalent in connecting local markets. One rail tanker car can hold from 200 to 700 barrels, but this transportation mode requires appropriate infrastructure, while it is not the most cost-effective.

Replacing a 1000 mile long, 150,000-barrel per day pipeline with a unit train of 2000-barrel tank cars would require a 75-car train to arrive and be unloaded every day, again returning to the source empty, along separate tracks, to be refilled (Tyler Carter-Mike Pescatore A). Transporting crude oil by rail has been growing quickly in the U.S. for a number of years but this trend is only now just emerging for crude oil originating from western Canada. Statistics Canada data reports 12,989 rail cars (1.1 million tons) were loaded in February 2013 transporting fuel oils and crude petroleum – a 60 per cent growth from February 2012 (Crude Oil Forecast, Markets & Transportation).

In the U.S. market the largest share of oil is transported via pipelines, but in areas where the pipeline infrastructure is deficient, railways move the shipments. It is widely known that the U.S.A. has had a developed rail network. According to the Association of American Railroads: "U.S. rail freight roads are the world's busiest, moving more freight than any other rail system in any other country. In fact, U.S. rail

roads move more than four times as much freight as do all of Western Europe's freight rail roads combined". Kazakhstan too has an extensive railways network used for both imports and exports of crude oil and its refined products.

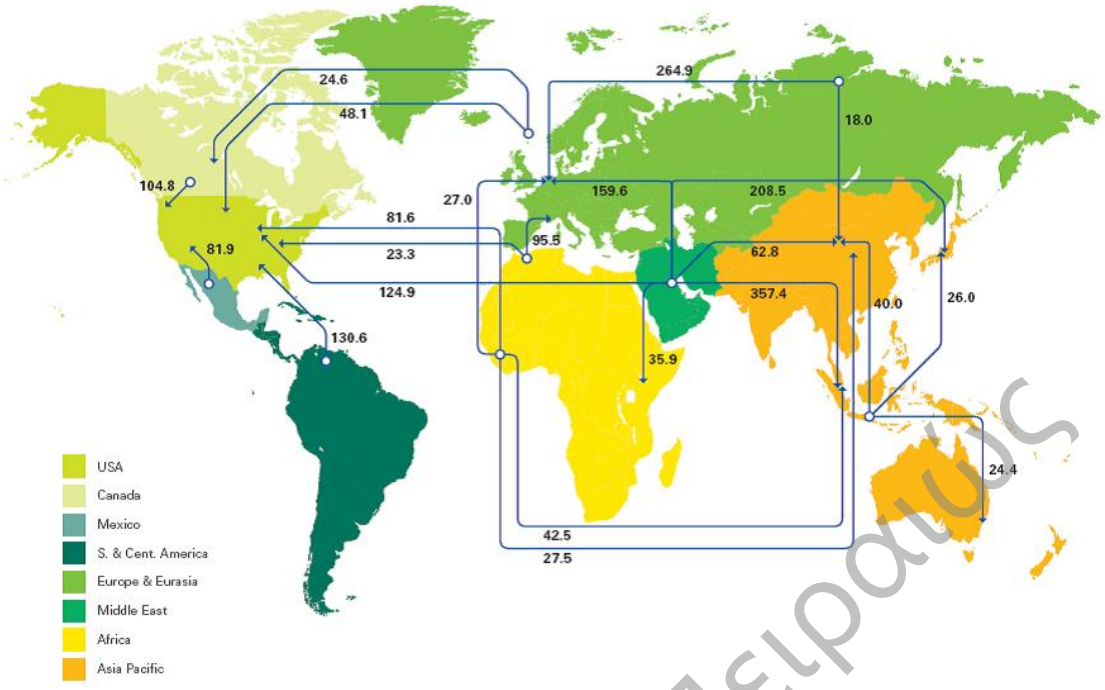
The last mode of oil transportation to be examined is the specialized trucks carrying crude oil and its refined products. Tank trucks are used for oil transportation through very short distances because the cost of transportation escalates steeply with distance.

Assuming each truck holds 200 barrels, traveling 500 miles per day, it would take a fleet of 3000 trucks, with one truck arriving and unloading every 2 minutes, to replace the same pipeline (Tyler Carter-Mike Pescatore B).

THE GLOBAL CRUDE OIL FLOWS

Oil trading patterns are currently shifting, while new players enter the global crude oil market. Demand growth is mostly concentrated in China and India, generally the Asia-Pacific region. In 2004 1750,4 mt of crude oil were transported from production to consuming areas. The Middle East, a region whose countries' economies are dependent on energy exports, exported 949,1 mt of crude oil, of which 124.9 mt imported the U.S.A., 159.6 mt West Europe, 208.5 mt imported Japan, 62.8 mt imported China, 357.4 mt imported Singapore and 35.9 ended up in East Coast of Africa. Another major exporter, Russia the world's third largest producer of oil as per 2004, exported at the same period 264.9 mt to West Europe and 18 mt to China. Nigeria's crude oil export trade held a significant share of the world total exports by exporting 81.6 mt to the U.S.A., 27 mt to West Europe, 42.5 mt to Malaysia and 27.5 to China. Nigeria is the largest oil producer in Africa and its oil and gas industries are mainly located in the Niger Delta. Venezuela is a founding member of OPEC and the biggest oil exporter in the Western Hemisphere. Venezuela's exports targeted the U.S. market and accounted for 130 mt. Another OPEC member, Algeria, exported in 2004 95.5 mt of crude oil to Southern Europe and 23.3 to the U.S.A.. Canadian crude oil exports through the pipeline network, which accounted in 2004 for 104.8 mt, targeted the U.S. market. Canada is dependent on the U.S.A as an export market. Indonesia, the most populous country in South-East Asia after China and India was an OPEC member until 2009. As per 2004 the country's crude oil exports accounted for 90.4 mt, of which 40 mt were exported to China, 26 mt to Japan and 24.4 mt to Australia. Mexico, one of the 10 largest oil producers, exported to the U.S.A. 81.9 mt of crude oil and finally North Sea's 72.7 mt of crude oil, 24.6 mt were exported to Canada and 48.1 to the U.S.A..

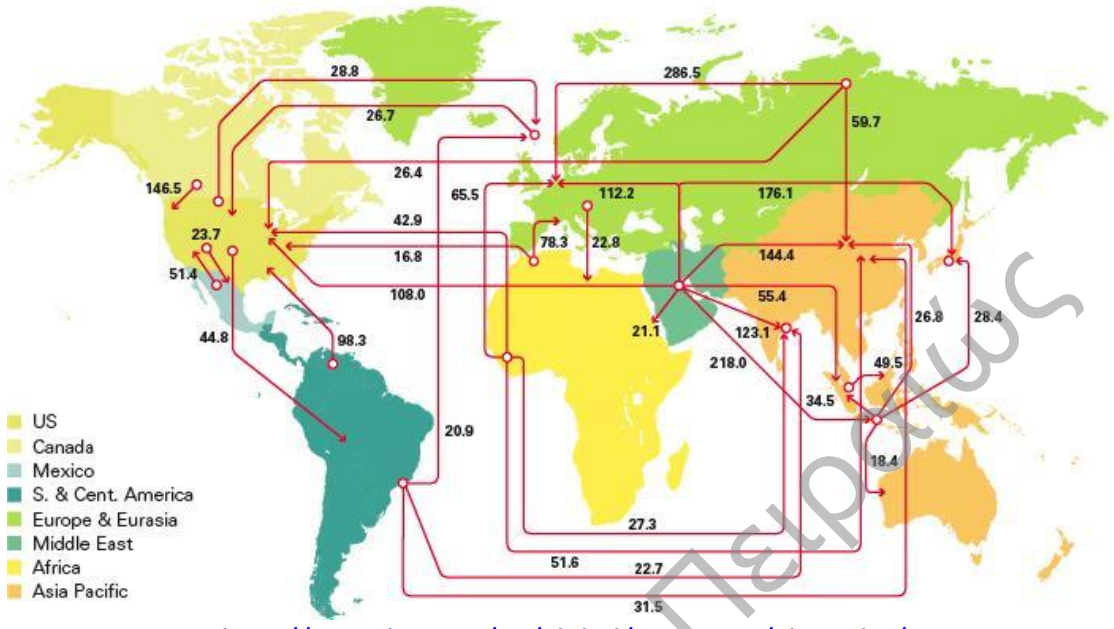
Figure 2.8: Major Trade Movements 2004 (million tons)



Source: BP Statistical Review of World Energy June 2005, p.19

The situation has changed sharply in 8 years. In 2012 2.378,4 mt of crude oil were traded globally. The Middle East increased its exports by 12.2 mt. In 2012 exported 958.3 mt of crude oil, of which 112.2 were exported to West Europe, 108 mt to the U.S.A., 21.1 to Africa, 273.4 mt to Indonesia, 123.1 mt to India, 144.4 mt to China and 176.1 mt to Japan. Russia, the same year, exported 372.6 mt of crude oil, of which 286.5 were exported to West Europe, 26.4 mt to the U.S.A and 59.7 mt to China. Nigeria, as per 2012, exported 187,3 mt of crude oil. Nigeria's biggest importer was West Europe by importing 65.5 mt, followed China with 51.6 mt, U.S.A. with 42.9 mt and India with 27.3 mt. Canada's crude oil exports as per 2012 accounted for 146.5 mt and entered the U.S. market, while Central Europe's crude oil exports for the same period accounted for 112.2 mt and entered the African market. Indonesia struggling to attract investments in order to satisfy its domestic energy demand, exported the same year 108.1 mt of crude oil. 34.5 mt were transported to Indonesia's North-West territories, 28.4 mt to Japan, 26.8 mt to China and 18.4 to Australia. Venezuela exported in2012 98.3 mt of crude oil and its main importer was the U.S.A.. As far as U.S.A.'s crude oil exports, they accounted for 97.3 mt in 2012. The biggest importer of U.S crude oil was the Latin America with 44.8 mt, followed the West Europe with 28,8 mt and finally Mexico with 23.7 mt. Algeria exported 95.1 mt, of which 78.3 were imported by Europe and the rest 16.8 by the U.S.A.. Brazilian crude oil exports reached 75.1 mt with China being the biggest receiver with 31.5 mt, India with 22.7 mt and Europe with 20.9 mt. Mexico's exports reached 51,4 mt and were imported by the U.S.A. in a bilateral trade. Malaysia exported 49.5 mt to Indonesia and North Sea exports of 26.7 mt were received by the U.S.A.

Figure 2.9: Major Trade Movements 2012 (million tons)



Source: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/review-by-energy-type/oil/oil-trade-movements.html

In these 8 years significant changes have been observed in the world oil market. The total oil trade has grown by 628 mt of crude oil. This increase is related to the reduction or oil producing cost and to the balance of demand and supply. The U.S.A. crude oil import trade increased by 26.3 mt. China's crude oil imports grew rapidly, more than 100%, during these 8 years by 165,7 mt. This steep growth is related to the country's development in industrial and export sectors, domestic economic growth and to the rapid population increase. For Japan the oil demand has declined since 2000 by almost 15% and this trend is related to fuel substitution by natural gas and other resources, to the population decline and to energy efficiency targets imposed by government. In 2012 Japan imported almost 30 mt of crude oil less than in 2004 and an even intense decrease in oil imports during the same period faced Indonesia. As far as the more industrialized part of Europe, West Europe imported in 2012 12,7 more mt of crude oil than in 2004 but less than 2009. This year to year reduction depends on the Europe's turn to other resources and more specifically to natural gas.

From the data aforementioned it is obvious that the seaborne trade flows of crude oil are mostly concentrated in the Strait of Hormuz, the world's most important chokepoint and is located between Iran and Oman connecting the Persian Gulf with the Gulf of Oman and the Arabian Sea.

Flows through the Strait in 2011 were roughly 35 percent of all seaborne traded oil, or almost 20 percent of oil traded worldwide. More than 85 percent of these crude oil exports went to Asian markets, with Japan, India, South Korea, and

China representing the largest destinations (www.eia.gov D). The Strait's daily flow in 2011 accounted for 17 mb. Significant traffic is concentrated in the Asia-Pacific region where the main importers, China, India and Japan are located. The Strait of Malacca, a key oil chokepoint, which is located between Indonesia, Malaysia and Singapore, connects the Indian Ocean to the South China Sea and Pacific Ocean and is the shortest energy pathway to China and Japan from the Middle East. Its estimated flow was, according to EIA, in 2011 15.2 mb/d. Crude oil exports from Brazil and Nigeria cross the Strait of Malacca. Through the Suez Canal pass exports from the Middle East heading to Europe and U.S.A.. Suez Canal's strategic position, located in Egypt and connecting the Red Sea and the Gulf Sea with the Mediterranean Sea, is a hub between the Southern and Northern Hemisphere oil markets.

In 2012, about 2.97 mb/d of total oil (crude oil and refined products) transited the Suez Canal in both directions. This is the highest amount ever shipped through the Canal and made up about 7 percent of total seaborne traded oil (www.eia.gov E).

Table 4: The Longest Oil Pipelines

Rank	Name	Length (miles)	Route
1	Druzhba Pipeline	2400	Northern Route: Belarus, Poland, Germany Southern Route: Belarus, Ukraine, Slovakia, Czech Republic, Hungary
2	Keystone Pipeline Phas1	2147	From Hardisty, Alberta, Canada to Wood River, Illinois, U.S.A.
3	Kazakhstan-China Pipeline	1384	From Atyrau, Russia to Alashankou China
4	Baku-Tbilisi-Ceyhan Pipeline	1098.6	From Baku, Azerbaijan to Ceyhan, Turkey
5	Tazama Pipeline	1060	From Dar es Salaam, Tanzania to Ndola, Zambia
6	Caspian Pipeline Consortium	940	From Tengiz field, Kazakhstan to Novorossiysk, Russia
7	Mumbai-Manmad-Bijwasan Pipeline	932	From Mumbai or Bombay to Manmad India
8	Baku-Novorossiysk Pipeline	830	From Baku, Azerbaijan to Novorossiysk, Russia
9	Trans-Alaska Pipeline	800	Prudhoe Bay, Alaska to Valdez, Alaska, U.S.A.
10	Baltic Pipeline System 1	730	from Timan Pechora to Primorsk Terminal

The Druzhba Pipeline also known as the Friendship pipeline is an energy line with a length of 2.400 miles, currently the longest oil pipeline. Through the pipeline's routes oil is transferred from Russia to Belarus, Poland, Germany, Ukraine, Slovakia, Czech Republic and Hungary. Operator of the Russian part of the pipeline is the oil company Transneft, Gomeltransneft is the operator for the Belarus Part, UkrTransNafta is the operator for the Ukrainian part, PERN Przyjazn SA for the Polish

part, Transpetrol SA for the Slovakian part, Mero for the Czech part and MOL for the Hungarian part. Pipeline's daily capacity accounts for 2mb/d.

The Keystone oil pipeline is another huge project of great importance. The Keystone oil pipeline is 2.147 miles long and connects Hardisty, Alberta, Canada through Regina, Saskatchewan and Steele City Nebraska to Wood River, Illinois, U.S.A.. The Pipeline's capacity accounts for 590 kb/d and its operator is TransCanada.

The Kazakhstan-China oil pipeline spans 1,384 miles, running from Atyrau port in northwestern Kazakhstan to Alashankou in China's northwest Xinjiang region, and has a capacity of 252,000 b/d of crude. The pipeline is currently being expanded to increase its capacity to 400,000 b/d. The additional capacity will be used to transport at least some Kashagan oil. The pipeline is a joint venture between CNPC and KMG (www.eia.gov F).

The Baku-Tbilisi-Ceyhan oil pipeline connects Baku, Azerbaijan through Tbilisi, Georgia, Erzurum, Sariz, Turkey and ends up at Ceyhan, Turkey. The pipeline has a length of 1.098,6 miles and a capacity of 1 mb/d and its operator is BP.

The Tazama oil Pipeline is the biggest pipeline in Africa, which transfers crude oil from Tanzania to Zambia. The length of the pipeline is 1060 miles long and its daily capacity is estimated to be 22.000 b. The pipeline's operator is Tazama Pipelines Ltd.

The Caspian Pipeline Consortium (CPC) oil pipeline was commissioned in 2001 and runs 940 miles from the Tengiz oil field to the Russian Black Sea port of Novorossiysk. The consortium's four largest shareholders are: Transneft 24 %, KMG 19%, Chevron 15%, and LukArco 12.5%). The pipeline consists of refurbished Soviet-era pipeline links along the Caspian and newly constructed components along the line. The consortium transported an average of 614,000 b/d of oil in 2012, and approximately 581,000 b/d between January and September 2013 (www.eia.gov G).

Another significant project is the Mumbai-Manmad-Bijwasan oil pipeline which was undertaken by Bharat Petroleum Corporation Ltd. This pipeline initially transferred oil from Mumbai or Bombay to Munmad and later expanded to Bijwasan.

The Baku-Novorossiysk Pipeline known as well as Northern Route Export Pipeline (NREP) connects Sangachal Terminal to Novorossiysk, Russia's port to Black Sea. The Pipeline is 830 miles long and its daily capacity reaches 100.000 b. The pipeline has been operating since 1996. Operator of the Azerbaijani section is SOCAR and of the Russian section is Transneft.

The Trans-Alaska Pipeline spans 800 miles, connecting Prudhoe Bay to Valdez, the northernmost ice-free port in North America. Its peak flow reached in 1988 2.1 mb/d, while its average flow as per 2012 accounted for less than 500.000 b/d. Alyeska Pipeline is the project's operator while the pipeline's owners are BP Pipelines (Alaska), Inc. 48.441%, ConocoPhillips Transportation Alaska, Inc. 29.2086%, ExxonMobil Pipeline Company 20.9943%, Unocal Pipeline Company 1.3561% as per September 2013.

Baltic Pipeline System 1 is an oil pipeline of great importance to Russian oil exports. This pipeline connects Timan Pechora to Primorsk oil Terminal and has a capacity of 1.5 mb/d. The pipeline's operator is Transneft.

CONCLUSIONS

In the following years China is expected to surpass the U.S.A. in oil imports. Russia's Eastern Siberian oil fields are a significant source for Chinese crude oil imports either through pipelines or oil terminals located in Russia's Far East like De-Kastri and Prigorodnoye terminal. China's crude oil imports through sea trade are expected to increase, due to the fact that oil transfers through sea trade long distances (Middle East-China) are the most cost-efficient. Consequently the traffic in South-East Asia region is going to increase and in the Middle East as well (Suez Canal, Red Sea, Persian Gulf and Arabian Sea). An increase in Suez navigation will induce an increase in navigation in the Mediterranean Sea. India has contributed to the already increased traffic in the South-East Asia region due to the year to year increased oil imports and the country's reliance on crude oil sea imports due to the lack of pipeline infrastructure. Despite the size of the country, its population and its energy demand, India includes a poor pipeline network in its Northern part. Crude oil imports via sea trade to U.S.A. rely mainly on its East Coast harbors. This means that the main Passages are from Middle East through the Suez Canal, from Middle East through the Cape of Good Hope or from North Sea and Latin America and West Africa through Atlantic Ocean. U.S.A.'s oil pipelines are the main mode for oil imports from Canadian Sands and through the completion of the Keystone XL Pipeline by 2015 the oil imports are going to increase by 830.000 b/d, half of what currently U.S.A. imports from the Persian Gulf. As afore mentioned, the Atlantic oil routes seem to multiply due to the increase to the Nigerian and Brazilian oil exports.

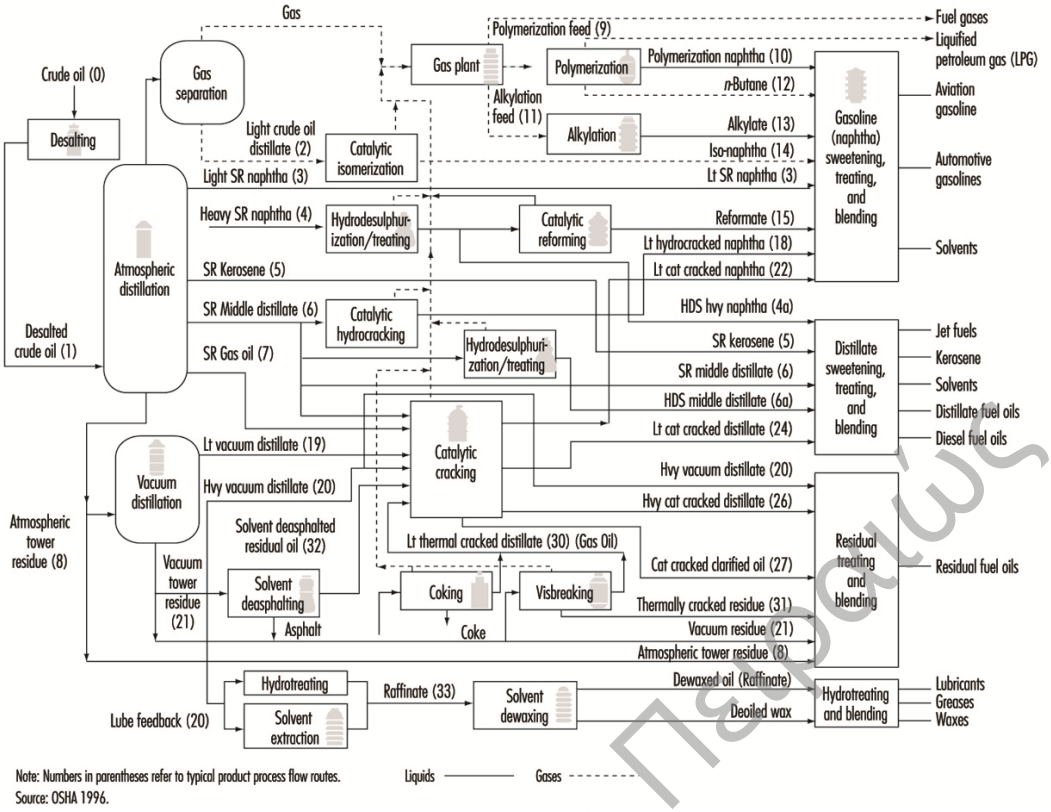
THE PETROLEUM PRODUCTS MARKET AND THEIR GLOBAL FLOWS

THE REFINING PROCESS

Petroleum products are the result of a complex process, called refining process. This process includes six stages: distillation, hydroprocessing, reforming/platforming, catalytic cracking, secondary treating and eventually blending. The selection of the appropriate type of crude oil is a significant factor to the aforementioned process.

More specifically, the first stage of crude processing known as distillation, or fractionation occurs in a column known as a Distillation Column. In this process, the crude oil, which is a mixture of many types of hydrocarbons, is boiled and recondensed to separate the crude oil into components based on ranges of boiling points. Components which are heavier are harder to boil and will collect in the lower part of the column. Lighter components are easier to boil and will be collected in the upper part of the column. Very heavy components which are unable to boil will leave from the bottom of the column, in a stream known as residue, while very light components will leave from the top of the column. This stream is known as Liquefied Petroleum Gas, or LPG. To meet environmental specifications or to assist its further processing, some components then undergo a process known as hydroprocessing. The objective of this process is to remove sulphur from the component stream. This process will consume hydrogen to assist in the sulphur removal. The sulphur removed from this process is converted into pure liquid sulphur and is sold to local industry for the production of acid and fertilizer. Reforming/platforming process converts a low value component called 'naphtha' into a product known as reformate or platformate. This reformate has a much higher octane number and is used for gasoline blending. This is achieved using a catalyst that contains platinum. Catalytic cracking is a conversion process, which involves the breaking up of large hydrocarbon molecules into smaller molecules using a combination of heat and catalytic action. The unit at SRC is a Long Residue Catalytic Cracking (LRCC) unit and takes a heavy hydrocarbon stream called Long Residue and converts it into a number of more valuable components and products, including LPG, Propylene and some Fuel Oil components. However, the main product form the SRC LRCC is a gasoline blending component known as Cat Cracked Gasoline (CCG). A by-product of this process is Coke (or carbon), which is burnt to generate steam and electricity. The refinery also has a number of smaller, so-called "secondary" processes. These are mainly involved with further polishing of components and products to remove sulphur and other impurities. The final stage of the refining process is called blending. This is a crucial step where the various hydrocarbon components manufactured in the refinery are mixed together to make the final products sold by the refinery. The final blend recipes will depend on the quality of the available components and on the customer's requirements, called specifications. All blended products are tested before they are sold to ensure that they meet the customer's specifications (www.shell.com).

Figure 3.1: Refining Process chart



Source: http://www.ilo.org/oshenc/part-xii/oil-and-natural-gas/item/384-petroleum-refining-process

The principal products of crude oil refining are hydrocarbon gases, distillates, residues and refinery by-products. More specifically the refinery products are the following: LPG, naphtha, aviation gasoline, automotive gasoline, jet fuel, kerosene, distillate fuel oil, diesel fuel oil, residual fuel oil, lubricants, greases and waxes. LPG is the lightest distillate which contains propane and butane. Distilled naphtha contains hydrocarbons which produce good quality gasoline, while kerosene's hydrocarbons produce a fraction suitable for processing to jet fuel. As the distillation process continues the fraction of atmospheric gasoil is the base for automotive diesel, heating diesel and diesel for industrial purposes production. At even higher temperatures the distillation products are residual fuel oil, lubricants, greases and waxes.

AN OVERVIEW OF THE REFINED PRODUCTS MARKET

According to CIA's World Factbook, the world's total consumption of refined petroleum products accounted as per 2011 for 256.588.581 b.. World's number one consumer is the U.S.A. with 18.840.000 b., followed by the European Union with 12.800.000 b. (as per 2012) and China with 9.790.000. Japan ranked fourth with an annual crude oil products consumption of 4.464.000 b., India fifth with 3.292.000 b., Russia sixth with 3.196.000 b. (as per 2012), Saudi Arabia seventh with 2.817.000 b.,

Brazil eighth with 2.594.000 b., Germany ninth with 2.400.000 b. and South Korea tenth with 2.310.000 b. (as per 2012).

The geographical position of the large refining centers that have developed is of great importance. Refining plants need to have instant access not only to crude oil markets but to refined products markets as well in order to become major hubs to petroleum products trade.

The most important such locations are the US Gulf Coast, Rotterdam in North West Europe (often referred to as ARA, Amsterdam-Rotterdam-Antwerp) and the Far East (Singapore). At a European level, the Mediterranean is also regarded as an important market (Overview of the European Downstream Oil Industry). Europe's largest refining hub is the North West Europe and more specifically the oil terminals in Rotterdam through which Germany and Switzerland are supplied. Another significant refining hub is the U.S. Gulf Coast, the largest U.S. refining center which is supplied with Texan, Venezuelan and Mexican crude oil. As far as the Far East, its primary refining hubs are China, Singapore, South Korea and Japan.

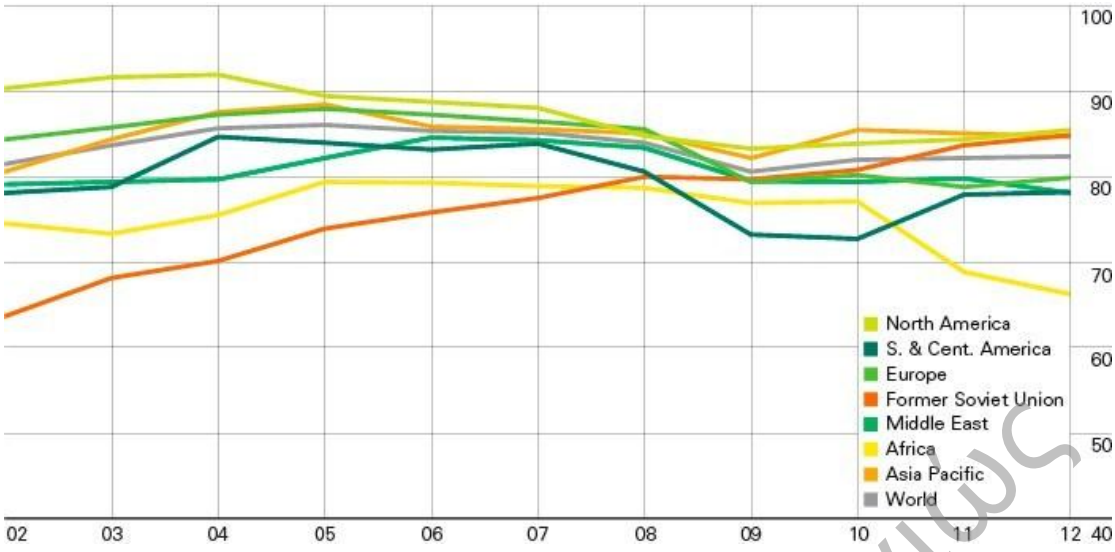
According to OPEC statistics the world daily refinery capacity accounted as per 2012 for 88.963,4 kb. Asia-Pacific region had for the same year the largest refinery capacity, which accounted for 25.640,4 kb/d, followed by North America with a total daily refinery capacity of 20.052,2 kb. Western Europe region had the third largest daily refinery capacity of 14.489,3 kb. while Eastern Europe had the fourth largest daily refinery capacity of 10.079,5 kb., followed by Latin America with 8.135 kb/d , Middle East with 7.277 kb/d and eventually by Africa with 3.289,6 kb/d. As far as the countries level the largest daily refinery capacity holds the U.S.A. with 18.142,4 kb., followed by China with 7.066 kb., Russia with 5.500 kb., Japan with 4.755,9 kb., India with 4.342 kb., United Kingdom with 3.425,5kb., South Korea with 2.958,5 kb., Germany with 2.247,3 kb., Italy with 2.195,2 kb. and finally Saudi Arabia with 2.107 kb..

As far as the total world petroleum product production, which as per 2012 accounted for 83.342,7 kb/d, the data are slightly different. The U.S.A. was the major petroleum product producer with 18.490,3 kb/d, followed by China with 9.175 kb/d, Russia with 6.436.1 kb/d, Japan with 3.748 kb/d, India with 3.487,1 kb/d, South Korea with 2.811,4 kb/d, Germany with 2.110,8 kb/d, Brazil with 2.064 kb/d, Saudi Arabia with 1.927,1 kb/d and Canada with 1.906,6 kb/d.

The total world petroleum products exports accounted as per 2012 for 23.172,11 kb/d, of which 18,8% holds OPEC. More specifically U.S.A. is the biggest "player" with total daily exports accounting for 2.698,4 kb. For the same year Russia's petroleum products exports accounted for 2.279,5 kb/d, Netherlands' exports accounted for 2.149,8 kb/d, Singapore's 1731 kb/d, Saudi Arabia's 862,1 kb/d, Venezuela's 675,1 b/d, Kuwait's 660,9 b/d, United Kingdom's 557,8 kb/d, Italy's 544,3 kb/d and China's 524,3 kb/d.

The total world petroleum products imports accounted as per 2012 for 20.688,9 kb/d, of which 6.6%, namely 1.374,4 kb/d, held OPEC. Singapore was as per 2012 the biggest petroleum products importer with 2.167,8 kb/d, followed by Netherlands with 1.909,3 kb/d, U.S.A. with 1.296,8 kb/d, Japan with 1.075,3 kb/d, China with 895,2 kb/d, France with 889,3 kb/d, Germany with 617,4 kb/d, Mexico with 601,3 b/d, Brazil with 569 b/d and United Kingdom with 530,1 kb/d.

Figure 3.2: Refinery Utilization Percentage



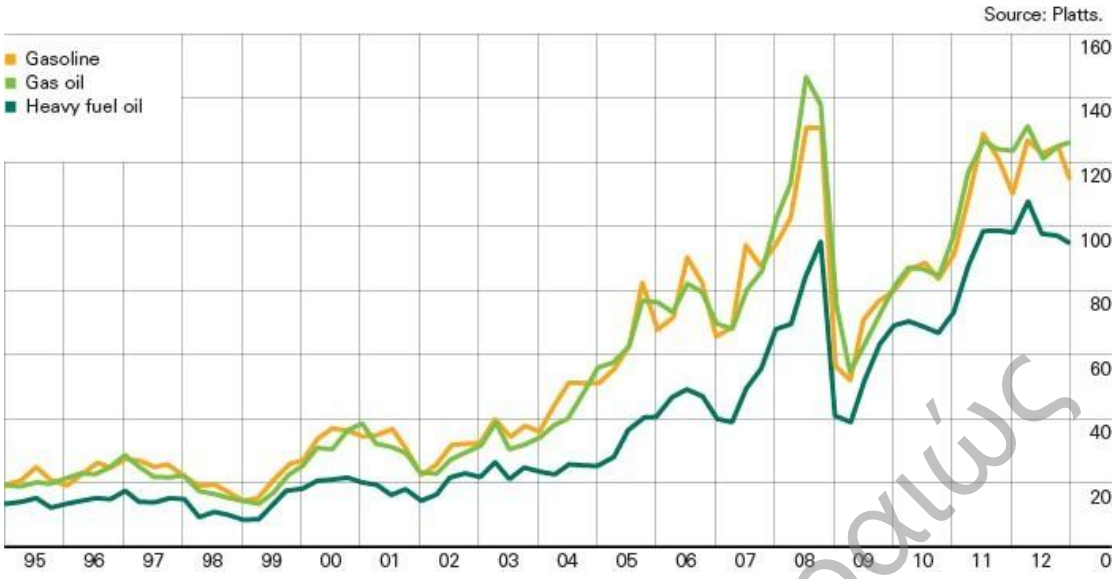
Source: BP Statistical Review of World Energy June 2013, p.17

The world refining hubs are being transferred from West to East while the Middle East and the Asia-Pacific region are becoming the major refining markets due to their planned projects to this sector. After more than hundred years of Western dominance the aforementioned regions are the major refining hubs due to the instant access to capital and crude oil markets. The economic recession which began in 2007 affected both the U.S. and the European refining market; the first was able to be supplied afterwards with cheap crude oil from unconventional sources while the latter saw many of its facilities to close.

Figure 3.3: Rotterdam Product Prices (U.S. Dollar per Barrel)

Source: BP Statistical Review of World Energy June 2013, p.14

Figure 3.4: U.S. Gulf Coast Prices (U.S. Dollar per Barrel)



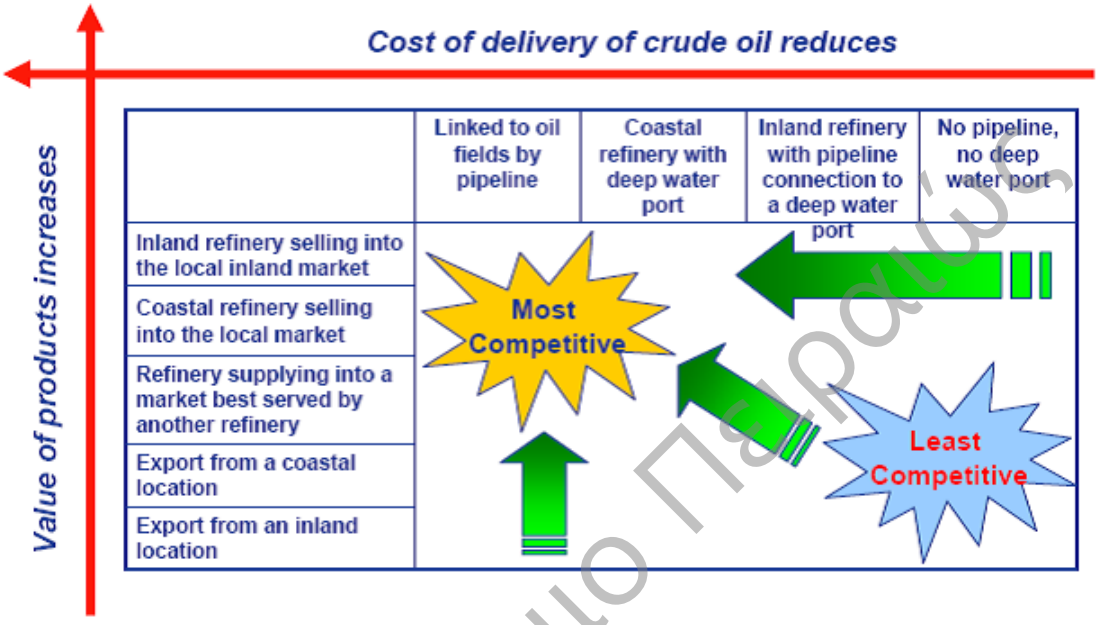
Source: BP Statistical Review of World Energy June 2013, p.14

THE PETROLEUM REFINERY

A petroleum refinery is a chemical plant which converts crude oil into several valuable products by removing the useless components. A refinery's main operations begin with the receipt of the crude oil and its storage. Since 1950 new methods of refining have been brought into the limelight, which established the promotion of the refined products to the local markets and simultaneously reduced the imports and the transport work, the tm. As aforementioned a petroleum refinery is usually located to crude oil, product and capital markets. A key factor which determines the refinery's market share is its logistics system, in other words the accessibility of the refinery through the existing infrastructure; pipelines, roads, terminals and railroads. Oil refining is a capital intensive business. The cost of a new built refinery accounts for 7-10 billion dollars, the acquisition cost of land not included and can vary depending on the location, the type of crude oil to be refined, the number of products, the size of the refinery and finally the environmental regulations imposed by the country's government. Not only its construction, but its operation is expensive as well. Both fixed and variable costs need to be dealt with. Some fixed costs are maintenance, insurance, salaries and administration costs, while variable costs are energy, feedstock and transportation costs. In order refineries to increase their efficiency, they should focus on their operational efficiency because it is almost impossible for them to affect the price of their input and output. Some key drivers to refinery's competitiveness are: the size of refinery, the age of refinery, the aforementioned logistics of the refinery, the configuration and the personnel of the refinery. As far as the size, large refineries benefit from economies of scale, while they need similar personnel, maintenance and management board as a smaller plant. Economies of scale are also met at the construction cost, while a refinery

twice the size of an identical other one, will cost from 1.5 to 1.75 times as much. Older refineries tend to be less cost-effective than new built, because they require more intensive maintenance and are less fuel-efficient as well. It is imperative that an oil refinery has access to many markets and this is feasible through its logistics. The accessibility of a refinery is critical for the maximization of cost and the acquisition of larger shares.

Figure 3.5: refinery competitiveness



Source: Overview of the European Downstream Oil Industry, Purvin&Gertz, p. 134

Another important key driver for the refinery's competitiveness is its configuration, which is the interconnection between the type and the relative size of the units that exist in the plant. Ultimately, the human resources of a refinery need to be skilled and motivated because they affect four main factors that define the plant's operating performance and these are the following: cost control, energy consumption, reliability and yields performance.

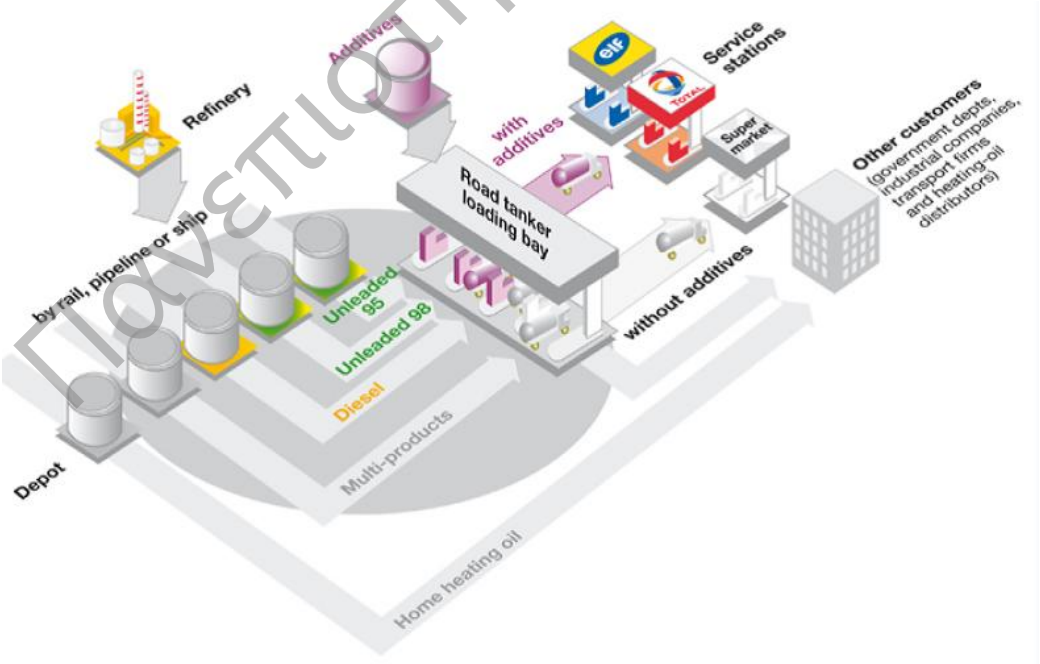
Currently, the largest refinery in the world is the Jamnagar refinery, which is located at Jamnagar in Gujarat, India and has an overall capacity of 1.24 mb/d. The plant is owned and operated by Reliance Industries. The second largest refinery in the world is the Paraguana refinery. The plant is located in Venezuela and more specifically in Paraguaná Peninsula in Falcón state and the western coast of Lake Maracaibo in the Zulia state, while its capacity is estimated to be 950.000 b/d. It was established in 1949 and it is owned by Venezuela's state-owned company Petróleos de Venezuela (PDVSA). The third largest refinery is located in South Korea and more specifically in Ulsan Metropolitan City, where derives its name from, and is the Ulsan refinery with a capacity of 810.000 b/d. Owner of the refinery is the SK Energy. Another South Korean refinery, the Yeosu refinery, is the fourth largest in the world and is located in Yeosu City in South Jeolla Province. The plant's capacity is 775.000 b/d and its operator is GS Caltex, a joint venture between GS Holdings and Chevron. The fifth largest refinery in the world is the Onsan refinery which is located in Ulsan in South Korea with a capacity of 669.000 b/d. The refinery is owned and operated

by S-Oil Corporation. The sixth largest refinery in the world is the Port Arthur refinery, which is located in the Gulf of Mexico at Port Arthur in Texas. The refinery's processing capacity accounts for 600.000 b/d, while the refinery's operator is Motiva enterprises, a 50/50 joint venture between Shell and Saudi Aramco. The ExxonMobil refinery which is located in Singapore is the seventh largest in the world, with a capacity accounting for approximately 592.000 b/d. The ExxonMobil refinery located in Baytown, Texas, U.S. is the eighth largest in the world and the second largest in the U.S.A. with a capacity of 584.000 b/d. The ninth largest refinery in the world and simultaneously the third largest in U.S.A. is the Garryville refinery whith a capacity of 520.000 b/d. Its operator is the Marathon Petroleum Corporation. The tenth largest refinery is the Ras Tanura refinery, which is located in the Persian Gulf in Saudi Arabia near the industrial port city Jubail. The refinery's capacity accounts for 500.000 b/d and its operator is Saudi Aramco.

THE DISTRIBUTION SYSTEM OF PETROLEUM RODUCTS

The distribution process of petroleum refined products is a complex operation which includes various means of transport and is more complicated than the distribution process of crude oil, although the quantities in the first case are quite smaller while the value of refined products is a lot greater than the value of crude oil .The distribution system procedure is the transport of the refined products from the refinery to the consumers. The modes of transporting the refined products include the product or chemical tankers, which are vessels less than 100.000 dwt, referred also as clean tankers, barges, rail, pipelines and specialized trucks known as

Figure 3.6: U.S. Petroleum Supply Chain



Source: The Transportation of Petroleum and Derived Products in the American Market

road tankers. Each mode has its unique part and is related to the size of market in which it is employed.

There are many channels of sale for refined petroleum products; retail, wholesale and bulk. Retail customers are these who use refined products for their everyday transportation and heating. Wholesale consumers are usually industrial customers, power plants, and airline or shipping companies. Bulk sales are usually sales of huge quantities made directly by the refinery. As mentioned in a previous chapter, the “clean” tankers, which are merchant vessels carrying refined petroleum products such as kerosene, gasoline, jet fuels or chemicals. The “clean” tankers are used to refined products trade among the national markets of the refined products by integrating them into one global refined petroleum products market. For instance product tankers that are employed in the Asia-Pacific region transporting gasoline from South Korean refineries to Japan. Through the sea trade of the petroleum products economies of scale are developed, reducing the unit cost, in this case the tm, although economies of scale in petroleum products trade are less important. The different sizes of product tankers are the following:

- Coastal is a vessel with a dwt from 3.001 to 10.000 and is usually employed in coastal waters with shallow drafts carrying kerosene, heating oil, jet fuels and chemicals.
- Small is a vessel with a dwt from 10.001 to 19.000, is the next size tanker and is usually employed in coastal waters with shallow drafts carrying kerosene, heating oil, jet fuels and chemicals.
- Handy or Handysize is a vessel with a dwt from 19.001 to 25.000 or from 10.000 to 34.999, employed more in local markets such as the Mediterranean.
- Medium or Handymax is a vessel with a dwt from 25.001 to 45.000 or from 35.000 to 49.999 employed more in short voyages.
- Long/Long Rage One (LRI) is a vessel with a dwt from 45.001 to 70.000 or from 45.000 to 79.999, employed in long voyages.
- Large/Long Rage Two (LRII) is a vessel with a dwt from 70.001 to 100.000+ or from 80.000 to 159.999, employed in long voyages.

For LPG (liquefied petroleum gas) trade specialized vessels, commonly referred as LPG carriers, are used. These specialized vessels are designed to carry propane, butane, butadiene, propylene and anhydrous ammonia. As of April 2014 the number of LPG carriers accounted for 1.272 and the order book until 2017 includes 191 LPG carriers. These vessels are categorized as follows:

- Fully pressurized are the simplest gas carriers and are fitted with two or three horizontal, cylindrical or spherical tanks, which operate at ambient temperatures. These vessels are not fitted with any reliquefaction plant. Their capacity ranges from 100 to 10.000 m^3.
- Fully refrigerated are the LPG carriers, which are designed to carry liquefied gases at low temperatures and pressure. The tanks of these LPG carriers have prismatic shape and contain nickel steel of 3.5%, which allows them to preserve temperatures of -48^oC, a bit lower than the boiling point of propane. Their capacity ranges from 15.000 to 100.000 m^3.

- Semi-pressurized and refrigerated are the LPG carriers which have a combination of the technical featured of the above mentioned types. Their capacity ranges from 2.000 to 20.000 m^3.

Barges are also used in refined products trade. Barges are used for short haul distances and contiguous trade, employed usually in inland and intracoastal waterways connecting interregional markets. Many refineries of Central Europe and U.S.A. use barges for the promotion of their output to the regional markets. Rail is another mode of transporting refined products through interregional markets. Rail's contribution to moving refined products to storage depots and consuming centers is of great importance. According to EIA, U.S.A. relies more on its railroad than on its pipeline network to move petroleum products due to its well-developed railroad network. Additionally, rail infrastructure is safer than pipeline infrastructure and it is not limited by environmental regulations. Pipelines are a refined products transporting mode as well and are commonly known as petroleum product trunk pipelines, transferring liquid petroleum products (gasoline, fuel oil) from refineries to oil terminals and from marine and pipeline terminal to storage depots and distribution centers. It is also very usual these product trunk pipelines to move liquid petroleum products to consumer storage facilities or directly to consumers, while is the most economically feasible mode of oil transportation from short haul to middle scale distances. Pressure, achievable through special compressors, is the main element and unlike in crude oil transfer, as far as refined products transfer, pipelines hold a smaller share. U.S.A. which is a mature product market has a vast crude oil and product pipeline network. Road tankers are the less economic efficient mode for the conveyance of the liquid petroleum products from distribution terminals to consumers e.g. gas stations and single consumers. This transport mode does not require any special infrastructure. Ultimately, petroleum products can also be transported in packaged form. The refined products are packaged by the manufacturer, in this case the refinery, in containers with a capacity accounting for 55 U.S. gallons or 45 imperial gallons or 205 liters.

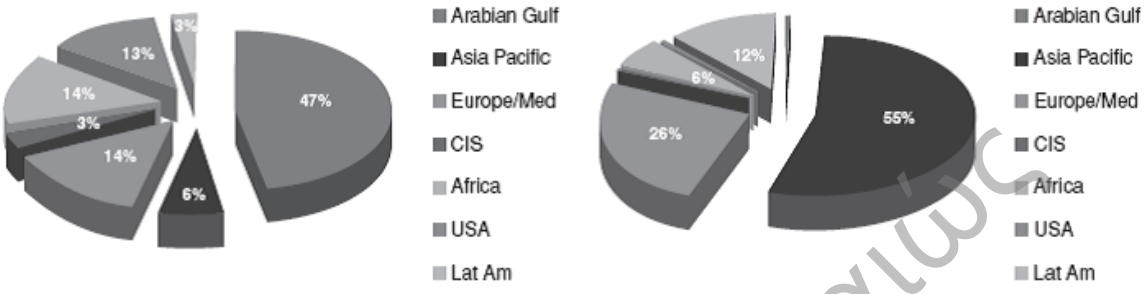
THE GLOBAL FLOWS OF REFINED PRODUCTS

THE LPG TRADE FLOWS

LPG trade flows are the same with crude oil flows because LPG is a gas found in crude oil reserves and LPG trade has been growing since 2000 with an annual rate of 4%. The LPG trading sector has witnessed significant changes during the last years. The LPG industry has a global "character" while seaborne LPG trade routes depend on the producing areas, consuming areas, seasonality and price differentials among regions. Regions which export LPG are categorized into two markets, "Western" and "Eastern" market. This categorization depends on the geographic location of each market and more specifically whether the market lies Western or Eastern of the Suez Canal. Western market includes the North Africa and North Sea regions, while the Eastern market includes the Arabian Gulf and the Asia-Pacific region. The Arabian

Gulf is not only the most important crude oil hub, but also a major LPG hub. Middle East's major exporters are Saudi Arabia, U.A.E. and Qatar supplying with LPG the Western markets and the Mediterranean and mainly the Asia-Pacific region. The Middle East region exported as per 2013 32.8 mt of LPG, of which 31.3 were transferred to Asia-Pacific region.

Figure 3.7: Global LPG Exports and Imports by Region as per 2013



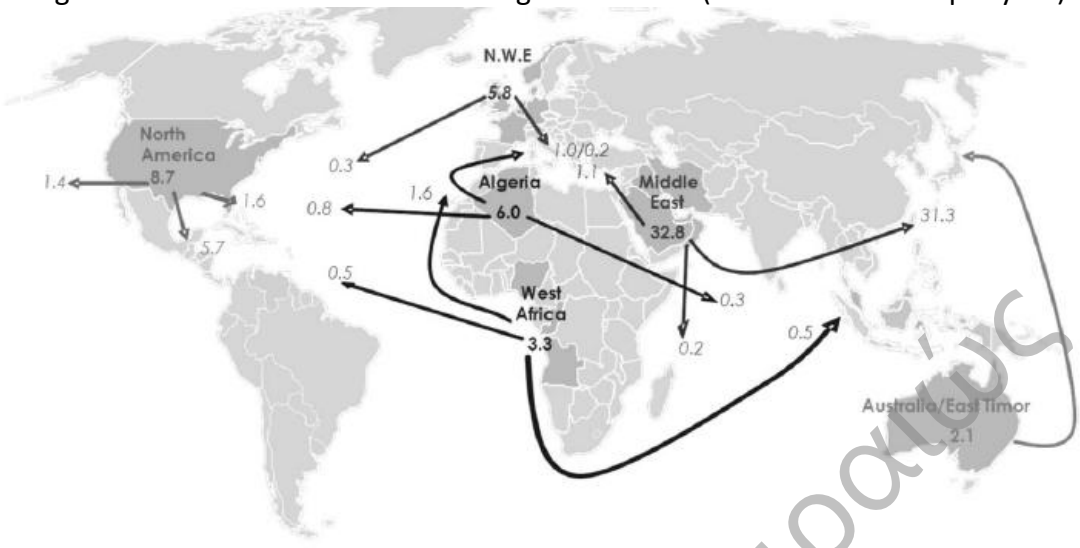
Source: Poten & Partners

Africa was as per 2013 the second largest exporter of LPG. The continents total exports accounted for 9.3 mt of LPG, of which 6 mt were exported from Algeria. 5.2 mt of Algerian LPG were transported to Mediterranean and Western Europe markets and approximately 0.8 mt were transported to North America. West African LPG exports (Nigeria, Equatorial Guinea and Angola) were 3.3 mt for the same year, representing approximately 5% of the international annual LPG trade, of which 1.6 mt were transported to Western Europe, 0.5 mt to Latin America and 0.5 to Asia-Pacific region. Europe was the third largest LPG exporter. Especially exports only from North Sea region (United Kingdom and Norway) and West Europe accounted as per 2013 for 5.8 mt of LPG, of which the largest share, approximately 5.5 mt, was transferred to other European consuming centers including Mediterranean Sea. The rest 0.3 mt were shipped to North and Central America. U.S.A, another major "player" in LPG trade was the fourth largest exporter with exports accounting as per 2013 for 8.7 mt, of which 5.7 mt of LPG were shipped to Central America, 1.6 mt to Caribbean and 1.4 mt to the Asia-Pacific region. Some minor "players" in the LPG trade exports are the Asia-Pacific region which as per 2013 held 6% of the total LPG exports and more specifically its most important exporting hub, Australia with 2.1 mt , which supplies China, South Korea and Japan , Latin America holding 3% of the total exports and C.I.S. holding 3% of the total exports.

As far as LPG imports the largest importer as per 2013 was the Asia-Pacific region holding 55% of the total LPG imports. China, Japan, South Korea and India are the largest importers of the region. Europe and Mediterranean region is the second largest LPG importer, holding 26% of the total LPG imports. Latin America was for the same year the third largest importer of LPG, holding 12% of the total imports. The largest importer of the Latin America, Brazil, held 25% of the regions imports, while some other major importers are Chile and Ecuador. Africa held as per 2013 6% of total LPG imports worldwide. According to Index Mundi, on country level, as per 2010 Japan was the largest LPG importer with imports of 646.610 b/d, followed by Netherlands with 315.240 b/d, South Korea with 194.180 b/d, U.S.A with 178.940

b/d, India with 142.510 b/d, China with 103.920, Mexico with 81.610 b/d, Turkey with 81.360 b/d, France with 74.370 b/d and Egypt with 72.650 b/d.

Figure 3.8: Main seaborne LPG trading routes 2013 (in millions of tons per year)



Source: Poten & Partners

THE CLEAN PETROLEUM PRODUCT TRADE FLOWS

The new trade patterns of petroleum refined products are shaped in the Asia-Pacific region and are quite similar to these of crude oil. The second wave emerging economies like China and India have totally affected the formation of the trade flows of refined products. Additionally, the concentration of refining plants in the Asia-Pacific region is quite observable, while five out of ten largest refinery facilities are located in the aforementioned region, having instant access both in capital and in crude oil markets.

Table 5: Distillate Fuel Oil Production, Exports, and Imports in barrels per day in 2010

Rank	Country	Production	Rank	Country	Exports	Rank	Country	Imports
1	U.S.A.	4.223.300	1	Russia	851.030	1	France	413.970
2	China	3.052.030	2	U.S.A.	655.960	2	Netherlands	385.330
3	India	1.607.900	3	Netherlands	636.080	3	Germany	318.980
4	Russia	1.431.170	4	India	415.610	4	U.S.A.	228.440
5	Japan	1.020.200	5	Singapore	376.760	5	Spain	220.710
6	Germany	918.090	6	South Korea	358.000	6	Turkey	194.840
7	Italy	809.340	7	Italy	218.340	7	United kingdom	192.960
8	South Korea	743.980	8	Japan	200.150	8	Indonesia	183.410
9	Brazil	711.680	9	Taiwan	176.080	9	Singapore	181.120
10	Saudi Arabia	633.450	10	Kuwait	151.840	10	Brazil	154.640

Source: http://www.indexmundi.com/energy.aspx?product=fuel-oil&graph=production&display=rank

From the table above referring to production and exports of distillate fuel oil as per 2010, it is obvious that the main players are the Asia-Pacific and the North America region including three European countries as well; Germany, Italy and Netherlands. Latin America contributes to the total production of distillate fuel oil through Brazil, a country with a daily capacity accounting for 711.680 b. As far as the imports of distillate fuel oil, Europe is the largest importer and more specifically France, Netherlands, Germany, United Kingdom and Spain, followed by U.S.A.

Table 6: Jet Fuel Production, Exports, and Imports in barrels per day in 2010

Rank	Country	Production	Rank	Country	Exports	Rank	Country	Imports
1	U.S.A.	1.417.740	1	South Korea	195.710	1	United Kingdom	157.380
2	South Korea	289.780	2	Netherlands	143.960	2	Germany	99.570
3	China	260.890	3	Singapore	137.220	3	U.S.A.	97.670
4	Russia	241.660	4	India	97.290	4	Hong Kong	93.400
5	Japan	239.050	5	U.S.A.	84.250	5	China	86.970
6	India	207.920	6	Venezuela	60.750	6	Netherlands	82.010
7	Singapore	180.610	7	Qatar	44.490	7	France	81.260
8	Netherlands	135.690	8	Bahrain	42.190	8	Singapore	73.520
9	United Kingdom	122.430	9	Japan	40.020	9	Spain	52.550
10	Germany	105.310	10	Kuwait	37.540	10	Australia	36.960

Source: http://www.indexmundi.com/energy.aspx?product=jet-fuel&graph=production&display=rank

U.S.A. is by far the largest producer of jet fuel with a capacity of 1.417.740 b/d. Asia-Pacific region is also a large producer of this refined product. Refinery facilities of South Korea, China, Russia, Japan, India, Singapore and Singapore produce daily 1.347.910 b. of jet fuel. Netherlands, United Kingdom and Germany are included to the ten largest producing countries of jet fuel. As far as the imports of jet fuel, the largest importers are developed countries with great airport infrastructure such as United Kingdom, Germany, U.S.A., Hong Kong, China, Netherlands, France, Singapore, Spain and Australia.

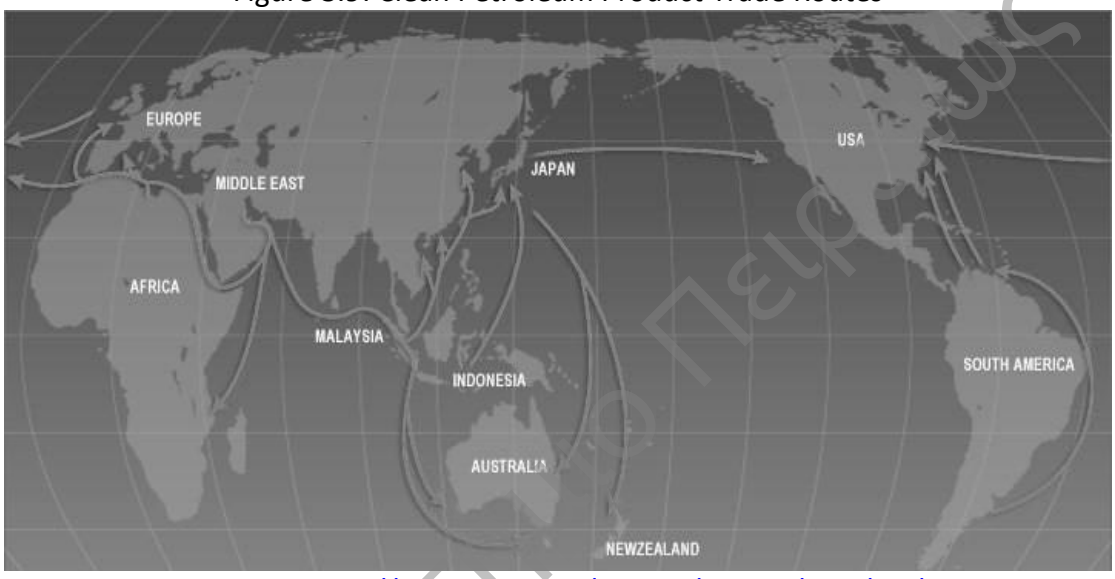
Table 7: Kerosene Production, Exports, and Imports in barrels per day in 2010

Rank	Country	Production	Rank	Country	Exports	Rank	Country	Imports
1	Japan	340.050	1	China	128.130	1	Nigeria	32.020
2	India	163.110	2	Kuwait	123.960	2	India	29.250
3	China	152.670	3	Saudi Arabia	103.790	3	China	18.360
4	Kuwait	124.780	4	South Korea	17.770	4	United Kingdom	17.680
5	Spain	116.740	5	Singapore	15.440	5	Ireland	16.990
6	South Korea	108.950	6	Ivory Coast	11.580	6	Netherlands	15.180
7	Saudi Arabia	98.840	7	Israel	11.010	7	Finland	14.050
8	Iran	96.870	8	Malaysia	9.170	8	Japan	11.270
9	United Kingdom	57.860	9	Netherlands	7.750	9	Italy	8.830
10	Indonesia	55.110	10	Thailand	7.140	10	Iraq	8.620

Source: http://www.indexmundi.com/energy.aspx?product=jet-fuel&graph=production&display=rank

As far as kerosene, the largest producer of this refined product was as per 2010 Japan with a daily production of 340.050 b., followed by India with 163.110 b/d and China with 152.670 b/d, while some great quantities are produced in Kuwait, Spain, South Korea, Saudi Arabia, Iran, United Kingdom and Indonesia. Kerosene production is mainly witnessed in Asia-Pacific region. China was the largest exporter of kerosene for 2010 as well. As far as Africa, the largest exporter of kerosene is Ivory Coast and referring to Europe the largest exporter is Netherlands, with its deep oil terminals. Nigeria was for the same period the largest importer of kerosene, while on continental level Europe was the largest importer with United Kingdom, Ireland, Netherlands, Finland, and Italy importing 72.730 b/d.

Figure 3.9: Clean Petroleum Product Trade Routes



Source: https://www.nyk.com/english/service/bulk/lpg/

Table 8: Motor Gasoline Production, Exports, and Imports in barrels per day in 2010

Rank	Country	Production	Rank	Country	Exports	Rank	Country	Imports
1	U.S.A.	9.058.630	1	Netherlands	382.940	1	Mexico	354.410
2	China	1.720.140	2	India	317.320	2	Indonesia	219.050
3	Japan	1.014.180	3	U.S.A.	295.790	3	Netherlands	217.960
4	Russia	840.150	4	Singapore	254.380	4	U.S.A.	134.270
5	Canada	719.230	5	United Kingdom	208.360	5	Nigeria	117.570
6	India	610.770	6	Italy	206.460	6	Iran	117.150
7	Germany	499.150	7	Canada	149.670	7	Saudi Arabia	86.190
8	United Kingdom	465.950	8	France	133.210	8	United Kingdom	85.330
9	Italy	438.010	9	China	120.820	9	Canada	78.390
10	Mexico	407.730	10	Germany	112.770	10	Malaysia	75.000

Source: http://www.indexmundi.com/energy.aspx?product=gasoline&graph=production&display=rank

The largest producer of motor gasoline was as per 2010 was by far U.S.A. with 9.058.630 b/d. Among the largest producers of motor gasoline were China, Japan, Russia, Canada, India, Germany, United Kingdom, Italy and Mexico. Although U.S.A. was the largest producer of motor gasoline, Netherlands is the largest exporter of this refined product, meaning that is a major hub for this distillate among others. As far as imports of motor gasoline, Mexico ranked as per 2010 the number one importer. European imports of motor gasoline are not that significant due to government regulations and policies referring emissions and shift towards motor diesel.

Table 9: Residual Fuel Oil Production, Exports, and Imports in barrels per day in 2010

Rank	Country	Production	Rank	Country	Exports	Rank	Country	Imports
1	Russia	1.238.080	1	Russia	1.141.930	1	Singapore	900.160
2	U.S.A.	584.910	2	Netherlands	477.300	2	Netherlands	532.320
3	Iran	480.470	3	U.S.A.	404.520	3	China	419.490
4	Saudi Arabia	445.420	4	Singapore	220.020	4	U.S.A.	366.150
5	India	427.910	5	Iran	184.360	5	U.A.E.	248.410
6	Japan	390.480	6	China	180.640	6	Hong Kong	154.440
7	China	389.070	7	Saudi Arabia	163.890	7	France	123.270
8	South Korea	341.190	8	Venezuela	160.080	8	Pakistan	121.540
9	Mexico	322.870	9	India	122.870	9	Belgium	84.580
10	Brazil	297.820	10	Mexico	122.610	10	Spain	60.220

Source: http://www.indexmundi.com/energy.aspx?product=residual-fuel-oil&graph=production&display=rank

CONCLUSIONS

The shift in refining industry from West to East is obvious. Developing and developed countries have contributed to this fact. From the data aforementioned the formation of the main refined product flows takes place to the Asia-Pacific region. Vast quantities of crude oil are extracted in the Middle East and transferred for distillation to the new built high-tech refineries of the Asia-Pacific region (China, South Korea, Japan, and India).

Demand for light distillates and fuel oil will be witnessed in the next years in Middle East countries, which plan to construct several refineries in order to meet the growing demand for refined products, driven by electricity production, water desalination and refinery fuel consumption. As far as North American and European markets, their demand for motor gasoline will probably continue to decrease due to environmental regulations referring to fuel emissions and probably due to the shift in hybrid engines which is growing very quickly. Many refineries in Europe since the financial crisis of 2008 have either shut down or reduced their throughput while many refineries in the U.S.A. started to have access to more economic feasible crude oil sources such as the Canadian oil sands and the Bakken Province, having a negative effect to refineries of Europe. Motor gasoline has been replaced by motor diesel. Motor diesel demand has been growing during the last 10 years and is

expected to grow a lot more due to its more eco-friendly emissions and its lower price compared to that of motor gasoline. Demand for motor gasoline in China is growing day by day. This fact is explained by the growing car ownership while the car fleet of China is expected to reach 266 millions by 2025. China plans to increase its refining capacities to 2.4 mb/d by 2018.

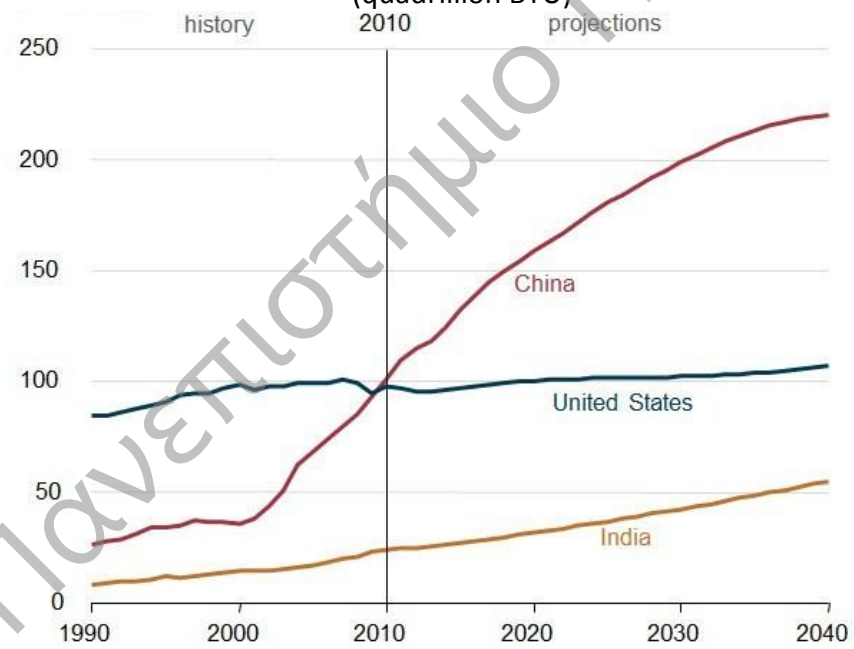
THE IMPACT OF LNG, CRUDE OIL AND REFINED PRODUCT FLOWS TO THE GLOBAL TRADE

THE GLOBAL ENERGY DEMAND

The global energy demand is the key driver of the formation of energy products trade flows. According to International Energy Outlook 2013, an increase larger than 85% is witnessed among the developing countries outside the Organization for Economic Cooperation and Development and is the result of economic development and population expansion. As far as OECD member countries, they are already mature energy markets where insignificant changes occur.

Another significant key driver of the formation of energy products trade flows is the GDP rise. The International Energy Outlook assumption is that the global gross GDP rises by an average of 3.6 % per annum from 2010 to 2040, with non-OECD economies averaging 4.7 % per annum and OECD economies 2.1 % per annum. The future energy growth consumption is mainly driven by non OECD countries.

Figure 4.1: Energy Consumption in the U.S.A., China and India 1990-2040 (quadrillion BTU)



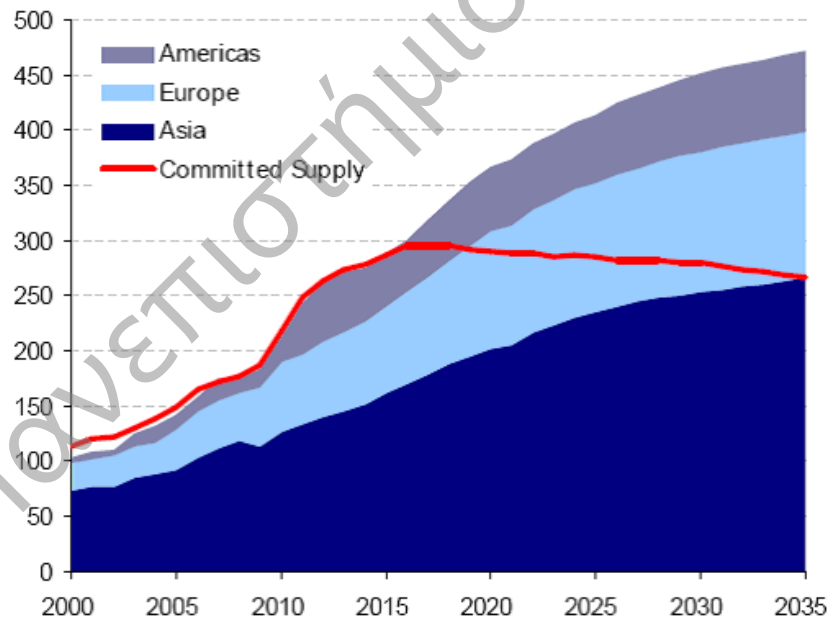
Source: http://www.eia.gov/forecasts/ieo/world.cfm

Among many economical and geopolitical factors the 2008 recession was a determinant factor who affected the energy markets globally. Economic recovery in the U.S.A. slower compared to previous recessions, while many European counties faced serious economic problems till the 2012. Non OECD countries were the leaders of the global recovery from the recession of 2008. More specifically China and India, two of the fastest growing economies in the world, during the 1990-2010. During this period, according to International Energy Outlook, China's economy grew by an average of 10.4 percent per year and India's by 6.4 percent per year.

THE IMPACT OF LNG TRADE FLOWS

According to Poten & Partners the demand of LNG is growing rapidly. During the decade 2000-2010 LNG demand has doubled more than 200 mt/y, when in 2010 the LNG demand accounted for approximately 100 mt/y and may take a great quantity of natural gas trade. LNG is becoming day by day more popular due to governments' restrictions referring to CO2 emissions. Poten & Partners project the global LNG trade to reach more than 360 mt/y by 2020, 400 mt/y by 2025 and 470 mt/y by 2035. Currently operating supply projects and projects that are under construction, according to analysts' expectations, will not meet the demand requirements. Developed and developing countries in the Asia-Pacific region will be the main LNG importers, while the demand for this product is estimated to grow with a rate of 2.7% per annum during the 2014-2035 and a supply deficit may occur in the beginning of 2016 if no other export projects are constructed by that time. Japan, South Korea and Taiwan, countries which rely on LNG in order to meet their energy demand have neither LNG resources nor extended pipeline network for imports and thus they import LNG through long-term contracts, securing their supply. Although China does have LNG resources, imports LNG through long-term contracts as well, because these resources are not able to meet the country's robust energy demand.

Figure 4.2: Global LNG Demand to Resume Growth Post 2009* (in million tons)



Source: Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal, p.5 *committed supply existing+under construction export projects.

The Asia Pacific market is comprised of three distinct segments, the traditional markets of Japan, Korea and Taiwan, the emerging markets of China and India, and niche markets, smaller new importers such as Thailand, Singapore and Pakistan. For the Asian market as a whole, committed supply is a real and growing

concern with a tight balance through 2012, and emerging wedge of needed new supplies starting in 2014 (Poten&Partners A). Japan is the largest LNG importer globally and includes 28 LNG import terminals; one of them is under construction and seven are expected to be constructed by 2018.

Seven electric utilities, Tokyo Electric Power Company (TEPCO), Chubu Electric Power, Kansai Electric Power, Tohoku Electric Power, Kyushu Electric Power, Chugoku Electric Power and Shikoku Electric Power accounted for approximately 65% of Japanese LNG imports in 2009. Other LNG buyers are the city gas distribution companies. Of the more than 240 city gas utilities, eight buy LNG. Tokyo Gas, Osaka Gas and Toho Gas are the largest city utilities. With relatively modest GDP growth projections of between 1 to 2%, Japan's LNG demand is projected to expand gradually, driven by further development of Combined Cycle Gas Turbine ("CCGT") power generation, and switching from oil to natural gas use in the industrial sector. Overall LNG demand is projected to reach 72 mt/y in 2015, 77 mt/y in 2020, 82 mt/y in 2025 and 85 mt/y in 2030. This translates into a compound annual growth rate ("CAGR") of1.4% between 2010 and 2020 and 1% between 2020 and 2030 (Poten&Partners B).

As far as South Korea, the second Largest LNG importer as per 2012, this country has very limited LNG resources and relies solely on imports in order to meet city gas production and power generation energy needs. According to Poten & Partners, South Korean imports fell by 12% in 2009 as a result of the global economic crisis.

With GDP growth projected to rebound from the global financial crisis to 4-5%, Korea's LNG demand is also projected to grow, driven by growth in Combined Cycle Gas Turbine (CCGT) power generation and in city gas use. Overall LNG demand is projected to reach 34 mt/y in 2015, 41 mt/y in 2020, 45 mt/y in 2025 and 49 mt/y in 2030. This translates into CAGR of 3.3% between 2010 and 2020 and then dipping to 1.7% between 2020 and 2030 (Poten&Partners C).

Taiwan began importing LNG in 1990 and as per 2012 was the fifth largest importer with imports accounting for 12.8 mt. Chinese Petroleum Corporation which is state-owned, is the unique LNG importer and is the operator of two terminals at Yung-An and Taichung.

Overall LNG demand is projected to reach 12 mt/y in 2015, 15 mt/y in 2020, 17 mt/y in 2025 and 18 mt/y in 2030. Taiwan's relatively temperate winter limits gas use for space heating in winter. However, its warm summer weather promotes the use of power generation to support the country's air conditioning load. Power generation accounts for over 80% of LNG use in Taiwan (Poten&Partners D).

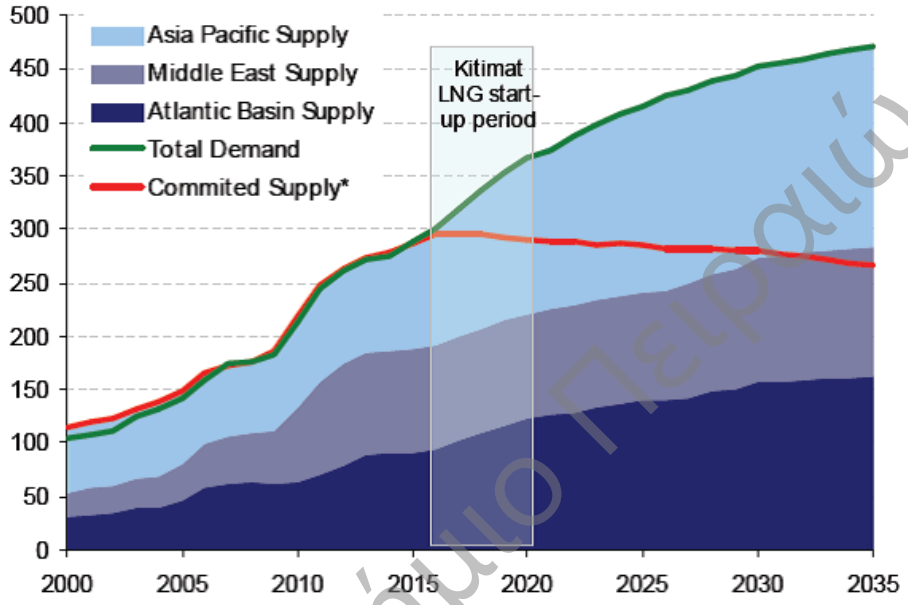
China, a very quick developing country, is a major importer of LNG and more specifically was as per 2012 the third largest importer with 18.6 mt. Due to the country's large resources in fossil fuel, China is not that reliant on LNG imports as the other Asian LNG importers. Coal was as per 2010 the dominant source for power generation with a share of 75%. Economic and population expansion will be the key drivers of LNG demand in China in the next years.

Total LNG demand is projected to reach nearly 63 mt/y (86 bcm/y) by 2035. As a number of LNG contracts expire in the early 2030s, only 12 mt/y is currently contracted in 2035. Pipeline imports could reach 55 Bcm/y by 2035 (40 mt/y LNG equivalent), but this is largely dependent on the development domestic gas supplies,

particularly unconventional gas (Poten&Partners E). China's developing economy is going to be greatly reliant on LNG and especially coastal cities all over China will be benefited through LNG imports in order to meet their energy demand.

As far as the production of LNG, Poten & Partners expect that three countries will be the dominant producers by the end of this decade; Qatar, Australia and Nigeria, with a total production of LNG accounting for more than 190 mt/y, representing more than 50% of the total global LNG production.

Figure 4.3: Global Supply Increasingly Dominated by Asia-Pacific



Source: Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal, p.18 *committed supply existing+under construction export projects.

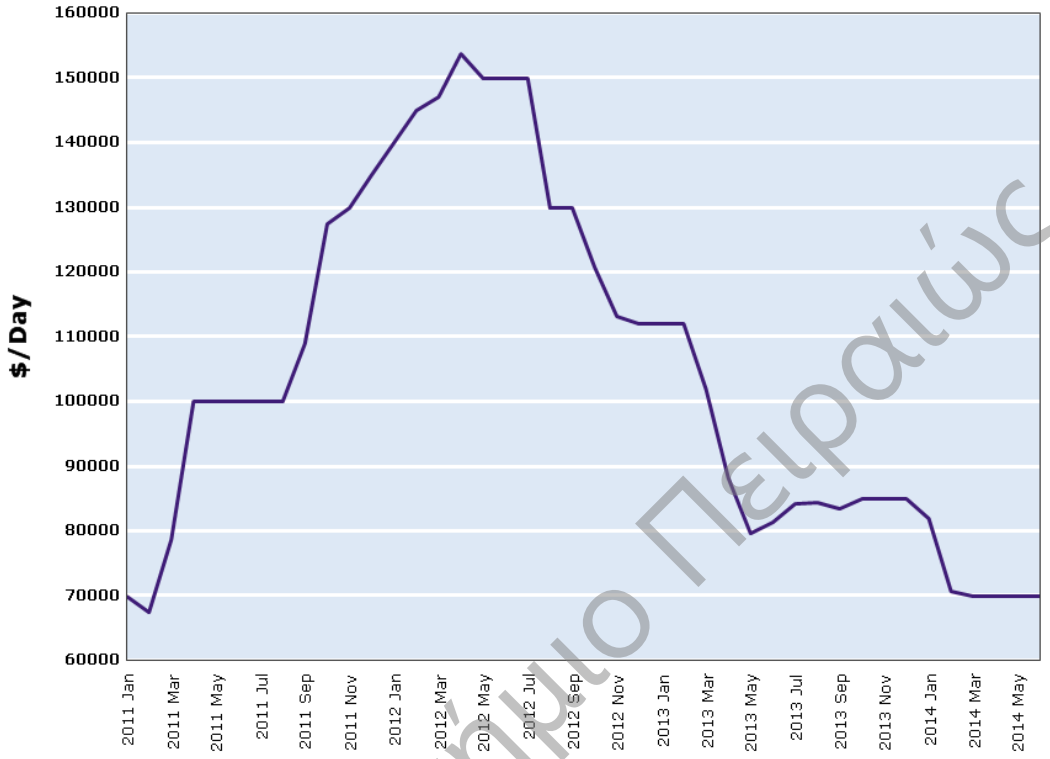
The Asia-Pacific region is the Leader in LNG production and according to estimates its production during the 2015-2020 will surpass the committed supply and will account from approximately 300 to 375 mt. For the same period the Middle East supply is estimated to account for approximately 180 to 210 mt, while the Atlantic Basin production is estimated to be from approximately 85 to 110 mt.

THE EFFECT OF LNG TRADE FLOWS ON CHARTER RATES

It is obvious that demand for a product, in this case for LNG, results in rise of demand for carriage of the abovementioned product. Especially now that LNG prices have dropped as a result of the decreased costs of regasification and liquefaction. LNG trade is a segmented market. The cost of purchasing an LNG carrier accounts for more than $220 million dollars but the asset values have remained the same since 2009. Additionally, the vast majority of these vessels are employed in long time charter contracts; a spot market never developed for such vessels. Currently, as per

July 2014, there are 375 LNG carriers, 105 in the order book compared to 5 as per 2010 and only 4 laid up.

Figure 4.4: LNG 160K CBM 1 Year Timecharter Rate

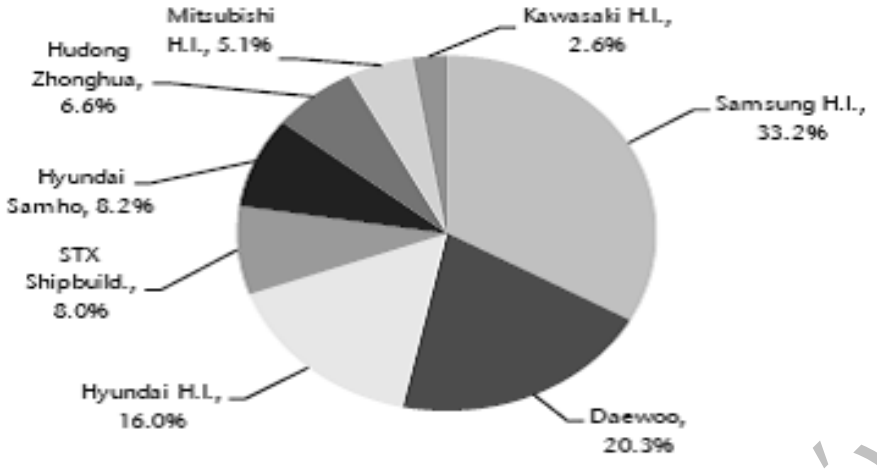


Source: Clarkson Research Services Limited

According to the figure above the LNG charter rates boomed right after the Japanese earthquake. In search for other sources of energy instead of nuclear energy Japan is the largest importer of LNG. LNG charter rates before the earthquake accounted for $40.000 to $70.000. The highest charter rates can be witnessed in January ’12 approximately $140.000 till March ’13 approximately $110.000+. Since then a downward move can be witnessed when by May ’13 time charter rates accounted for approximately $70.000. LNG demand is expected to grow in 2015, a fact that can positively affect the time charter rates of LNG carriers. This demand is going to be developed mainly in the Asia-Pacific region.

Currently there are only 8 shipyards that build LNG carriers. This is a relatively small number compared to the LNG market size.

Figure 4.5: Shipyards percentage as per 2013



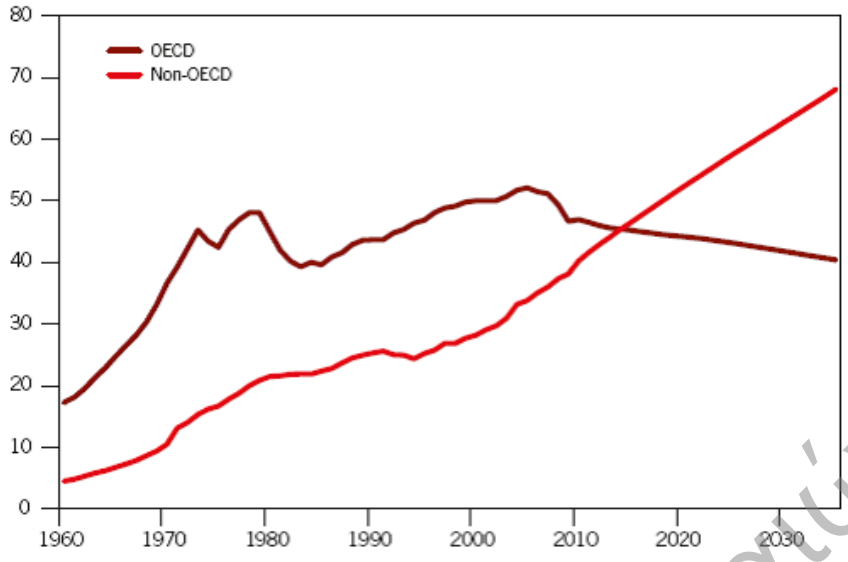
Source: Clarksons

The above shown shipyards possess the know-how for the LNG shipbuilding. The 105 LNG carriers are going to be built by these shipyards. It is of great importance the possibility of more shipyards construction. The greater the numbers of shipyards building LNG carriers, the faster the deliveries are going to be done and more vessels are going to entry the market. A phenomenon witnessed in other shipping sectors, called speculative ordering, in LNG shipping is limited due to great capital requirements and limited bank financing. If by 2015 all LNG vessels are employed and none of them is laid up, there are going to be 484 vessels in the market. Initially an oversupply of vessels might be witnessed but according to estimations the time charter rates are going to increase by the end of 2015 beginning of 2016 due to the upcoming demand for LNG in the Asia-Pacific region, mainly led by China and Japan.

THE IMPACT OF CRUDE OIL FLOWS

Increasing crude oil demand is mainly witnessed in developing countries. Although as per 2012 U.S.A. was the largest importer of crude oil followed by China, japan and India. Oil demand is related with economic development, growth population and generally factors indicating a development of a country. The transportation sector is the one which demands the largest share of crude oil, a share accounting for 57% as per 2010. The second largest share held for the same year the industrial sector, a share accounted for 26%, followed by residential/commercial/ agricultural sector with 11% and electricity generation sector with 6%. According to estimations of World Energy Outlook by OPEC, by 2035 transportation sector's crude oil demand share is going to increase to 60% while the other three sectors will experience a decrease which accounts for 1% and thus industrial sector will hold a share of 25%, residential/commercial/ agricultural sector 10% and finally electricity generation sector 5% of total oil demand.

Figure 4.6: OECD and non OECD Oil Demand in mb/d

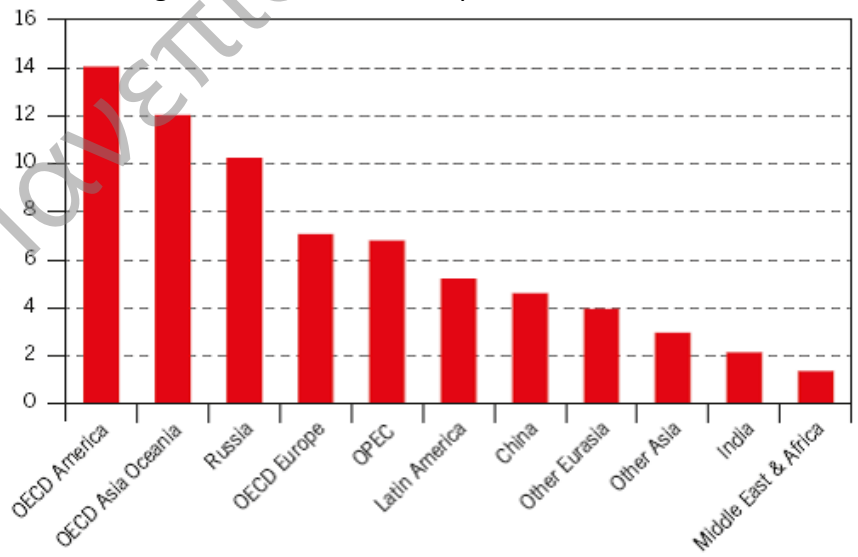


Source: World Energy Outlook 2013, p.58

World oil demand, according to World Oil Outlook 2013, is estimated to account for 108.5 mb/d as per 2035. Developing countries in Asia will hold 88% of the total growth and more specifically China, India and the rest developing Asian economies will hold 94% of the abovementioned 88%.

By 2035, oil use per head in developing countries will still average just 3.2 barrels – up from 2.4 in 2012 – compared to close to 11 barrels on average in the OECD – down from over 13 in 2012. By 2035, while over 14 barrels per person per year will be consumed in North America, and 12 in OECD Asia Oceania, in India this ratio will still be only 2 barrels per head, and only just over 1 barrel in the Middle East & Africa region (World Oil Outlook A).

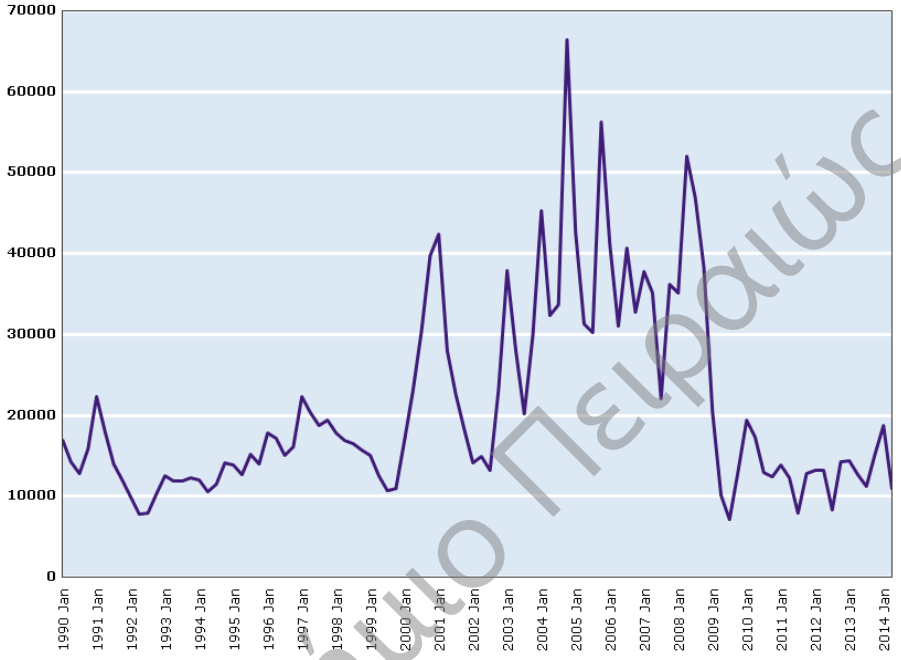
Figure 4.7: Oil Use Per Capita in 2035 in Barrels



Source: World Oil Outlook 2013, p. 59

This increasing demand will certainly result in an increasing demand for transport services of crude oil in the future. As far as the tanker charter rates seem to present their peaks and throughs which are affected by various factors. From the table above the fluctuations are obvious in very particular time periods when the balance between demand and supply was not equal.

Figure 4.8: Clarksons Average Tanker Earnings in $/d



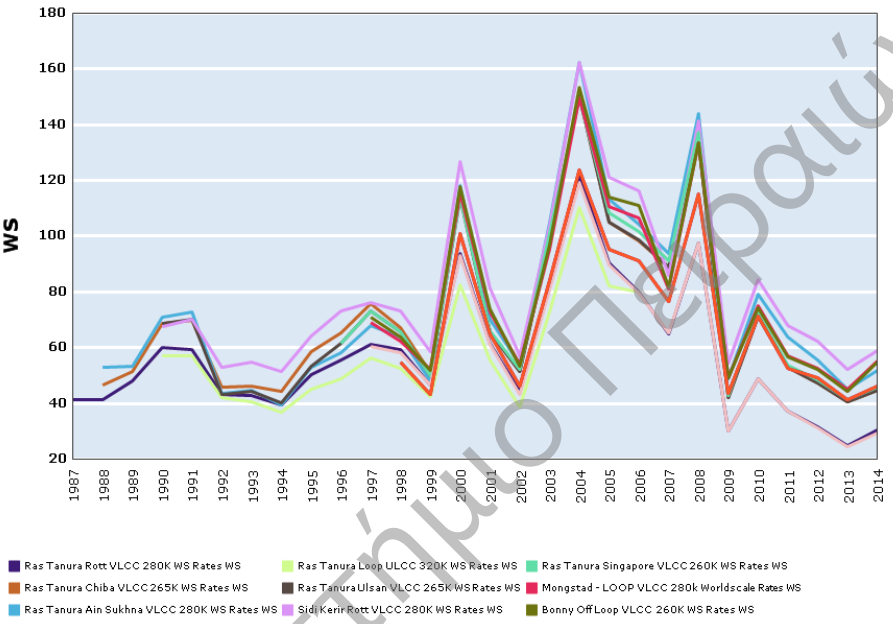
Source: Clarksons Research Services Unlimited

During January 1991 average tanker rates increased up to $20.000. During the period of Gulf War many charterers used the contango method, according to which the crude oil tankers are used as floating storage tanks and thus these vessels are temporarily removed from the charter market. Since the beginning of 1992 till middle of 1995 a recession in tanker market was caused by the oversupply of new-built vessels. Consequently tanker market started to bounce back and the tanker freight rates started to improve slowly but surely until the end of 1996, when the 1997 Asia Crisis, which affected mainly Indonesia, South Korea and Thailand and incidentally Hong Kong, Malaysia, Laos, Philippines, while China, Taiwan, Singapore, Brunei and Vietnam were less affected, had a negative influence on average tanker earnings until 2000. In December 2000 an increase in average tanker earnings was observed, which was affected by the mini energy crisis in U.S.A., leading to vast imports of crude oil in order to meet the energy demand. The 21st September incident had a significant influence on average tanker earnings when the tanker charter rates accounted for approximately 40% Worldscale, the lowest percentage since 1987 till that time. Year 2003 was the beginning of an upwards movements of tanker freight rates when Venezuela strikes increased long haul trade and delays in Turkish Straits occurred. Especially 2004 was a year of extreme profitability for ship

owners, a period when a VLCC was employed from Sidi Kerir to Rotterdam at a plus 160% Worldscale(figure below).

This increasing demand will certainly result in an increasing demand for transport services of crude oil in the future. As far as the tanker charter rates seem to present their peaks and throughs which are affected by various factors. From the table above the fluctuations are obvious in very particular time periods when the balance between demand and supply was not equal.

Figure 4.9: Ras Tanura VLCC 280K Worldscale Rates



Source: Clarksons Research Services Unlimited

Year 2005 is considered a year of high income flow for ship owners. Hurricane Ivan disrupted U.S. Gulf production, a fact that led to increased long haul crude oil imports, while OPEC's production increased by 2 mb/d. in 2006 was the fourth year of a continuous profitability and thus many investments in new-built tankers were made. During 2007 a slight decrease in tanker freight rates was witnessed and the order book of tankers increased by 77% accounting for 49% of the existed fleet. Two facts were negative signs for the next years; barrel's price accounted that year for $100 and the beginning of the global recession, which was triggered by Lehman Brothers' collapse. Year 2008 was a year of extreme volatility for the tanker market. Bunker prices rose from $450 to $750/ton. In the beginning of the year a Capesize tanker was employed in the spot market for $130.000/d, while in early February the same vessel was employed for 40% less than it was little earlier. In June a Capesize was employed in the spot market for $320.000/d due to the need for iron ore stock and port congestions. In early September this Capesize was employed in the spot market for $80.000/d and while the global recession was becoming more intense it was employed in the spot market for $6.000/d in October and for $2.000/d in November. Year 2009 average tanker earnings were extremely

low and tankers operated below the break-even point, while in 2010 the average tanker earnings improved at $20.000/d and since then a downwards movement of World Scale is observed with a slight improvement since December 2013.

The tanker shipping market includes several markets, which are closely related and affect each other. As far as the order book of crude oil tankers there are currently, as per July 2014, according to Clarksons Shipping Intelligence Network, 83 UL/VLCC, 45 Suezmax, 118 Aframax, 38 Panamax, 513 Handysize, 70 Small (5.000-9.999dwt) and 8 Shuttle tankers, meaning that 875 vessels or 70.470.062 dwt will enter the tanker market and their delivery will take place between July 2014 and 2016. This means that an oversupply of tanker vessels will be observed in 2015 until the crude oil demand, which is expected to start rising after 2016, balances the situation. Demand for sea transportation services is not only dependent on the volume of the transported cargo, but also on the average haul. Trading patterns change, since crude oil consumption is mainly witnessed in the future in non OECD countries. Scrapping is also a significant factor to the tanker charter rates formation, which triggers optimism. By 2012 scrapping was almost 46% more than the existing order book and more specifically accounted for approximately 580 vessels. It is rather unlikely that the tanker charter rates will soon be at the level of 2004 and 2008. It is very possible that the tanker charter rates will rise due to the increasing demand for crude oil, which is expected to occur between 2016 and 2035.

THE IMPACT OF REFINED PRODUCT FLOWS

The global crude oil market is the source of the refined product market. The geographical distribution of refining plants between OECD and non OECD countries is quite uneven, while the largest share of it is concentrated in the Asia-Pacific region. According to World Oil Outlook 2013, the global demand for refined products is projected to grow by approximately 20 mb/d between 2015 and 2035.

Figure 4.10: Global product demand, shares and growth, 2012–2035

	Global demand *mb/d*						Growth rates *% p.a.*		Shares *%*	
	2012	2015	2020	2025	2030	2035	2012–2020	2020–2035	2012	2035
Light products										
Ethane/LPG	9.7	10.0	10.5	10.9	11.2	11.5	1.0	0.6	10.9	10.6
Naphtha	5.9	6.2	6.8	7.3	7.9	8.5	1.6	1.5	6.7	7.8
Gasoline	22.7	23.3	24.4	25.5	26.5	27.5	0.9	0.8	25.6	25.3
Middle distillates										
Jet/Kerosene	6.5	6.7	7.1	7.4	7.7	8.1	1.0	0.9	7.3	7.5
Diesel/Gasoil	25.8	27.3	30.0	32.2	34.1	36.0	1.9	1.2	29.0	33.2
Heavy products										
Residual fuel*	8.2	7.8	7.1	6.6	6.3	6.0	–1.8	–1.1	9.2	5.5
Other**	10.0	10.2	10.5	10.7	10.8	10.9	0.7	0.3	11.2	10.1
Total	**88.9**	**91.6**	**96.3**	**100.7**	**104.6**	**108.5**	**1.0**	**0.8**	**100.0**	**100.0**

Source: World Oil Outlook 2013, p. 180

The most important growth is witnessed in middle distillates section, jet/kerosene and diesel/gasoil. Medium-term, from 2012 to 2020 jet/kerosene is projected to grow with an annual rate of 1% and long-term, from 2020 to 2035 is projected to grow with an annual rate of 0.9%. As far as diesel/gasoil, it is expected to grow medium-term with an annual rate of 1.9% and long-term with an annual rate of 1.2%. From light distillates the fastest annual growth rates develops naphtha, while heavy products and more specifically residual fuel develops both short-term and long-term negative annual growth rates.

According to WOO 2013 Asia-Pacific region had as per 2012 the largest demand for refined petroleum products, totally 19.1 mb/d. China and India are the main drivers for this demand. Both developing countries with very quickly expanding populations and car fleet are dependent on great gasoline imports. Asia-Pacific's demand for this refined product is projected to account in 2020 and 2035 for 6.1 and 9.3 mb/d respectively. As far as ethane/LPG and jet/kerosene demand is projected to increase while residual fuel demand is projected to remain stable till 2020 while long-term is projected to reach 1.9 mb/d.

Africa's demand for gasoline is also projected to increase both medium-term and long-term. The region's demand in 2020 is estimated to be 1 mb/d and in 2035 1.4 mb/d. As far as diesel/gasoil demand, it is projected to account as per 2020 for 1.8 mb/d and as per 2035 for 2.3 mb/d.

Indeed, Africa is the only region where residual fuel oil demand will not decline throughout the entire period, despite the effect of IMO regulations on marine bunkers. Recent growth in residual fuel oil demand for electricity generation in the region is likely to continue, with the impact of expanding inland consumption expected to offset the decline in bunker fuels. Adding in 'other products' sees total heavy product demand in Africa increasing by 0.3 mb/d over the forecast period (World Oil Outlook B).

European demand for refined petroleum products is projected to decrease both medium-term and long-term. The new trend for Europe is the LNG. This trend is being supported by governments' policies and regulations from IMO referring to marine bunkers' maximum sulphur content in ECA's after 1st January 2015. Due to the latter, diesel demand is projected to increase. Gasoline demand decreases both medium-term and long-term as well. Europe's passengers' car fleet turns to diesel.

Europe's demand for jet/kerosene is projected to decline, albeit marginally. This is the result of structural changes within this product group, with modest increases in jet kerosene demand, being offset by losses in the domestic and industrial use of kerosene. A decline in naphtha demand reflects the trend in the 'relocation' of the petrochemical industry to developing countries, especially from Western Europe. In Central and Eastern Europe, however, naphtha demand is expected to grow (World Oil Outlook C). The largest decrease is projected to take place in residual fuel oil and other distillates sector such as bitumen, lubricants, waxes, still gas, coke, sulphur, direct use of crude oil, etc.

Refined product demand in Russia & Caspian region is expected to increase by 0.6 mb/d from 2012 to 2035. The main drivers of this increase are gasoil/diesel and gasoline, the transportation sector. The European shift towards diesel as

transportation fuel is witnessed in Russia & Caspian region too. IMO regulations referring to Baltic Sea ECA and the minimization of the number of trucks and buses, which use gasoline as fuel, have contributed to the rise in diesel demand.

Growing natural gas production in the region will also play a role in respect to naphtha demand. It is expected that a portion of the petrochemical industry's additional feedstock will be based on natural gas, including the use of currently flared gas, which should be almost eliminated within the next few years. As a result, lower than average increases are projected for naphtha, despite the region's expanding petrochemical industry (World Oil Outlook D).

Latin America's demand for refined petroleum products is mainly driven by two distillates; gasoline and gasoil/diesel. This rise in demand for the aforementioned products is solely relied on the expanding car fleet using gasoline and truck and bus fleet using diesel in Latin countries. Jet/kerosene demand is expected to rise as well. The countries driving this demand are Brazil, Argentina and Venezuela due to their increased air traffic. Brazil's demand for naphtha is also projected to increase due to the country's petrochemical expansion. Latin America's share of LPG is the highest globally.

Over the forecast period, LPG demand will broadly maintain its share and increase by some 0.2 mb/d. The only product that is set to decline is fuel oil, which drops by 0.3 mb/d by 2035. Around half of this decline is related to the fuel switch between IFO and diesel oil in the marine sector. In total, demand for refined products in Latin America is set to increase by 2.6 mb/d between 2012 and 2035, which represents an average annual growth of 1.1% p.a. Growth is stronger in the medium-term, at around 1.7% p.a., with rates gradually declining over the longer term to below 1% p.a. (World Oil Outlook E)

Middle East's product demand for petroleum refined products is projected to grow from 7 mb/d in 2012 to 9.7 mb/d in 2035. The main drivers for the rise of the demand are gasoil/diesel and gasoline, while naphtha is expected to contribute slightly in this rise. Jet/kerosene demand is expected to grow slowly and steadily, a growth accounting for 0.2 mb/d from 2012 to 2035. As far as residual fuel oil demand, is projected to remain stable during the forecast period. The main factors for the rise of the demand for refined products are the expansion of refining projects, the car fleet expansion and the development of transport infrastructure.

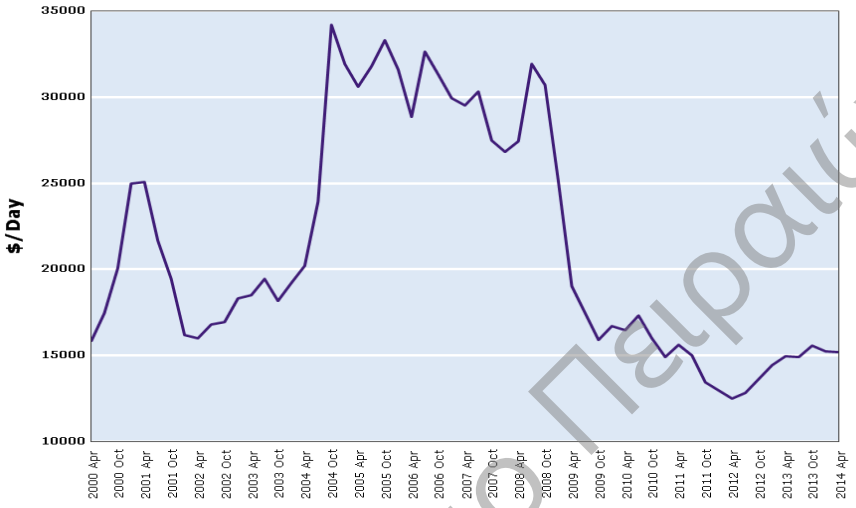
Medium-term, until 2020, North America's demand for refined petroleum products is projected to be stable; while long-term the demand is expected to decrease. According to WOO 2013, the region's demand for refined products is estimated to fall by more than 2mb/d between 2012 and 2035. Diesel/gasoil is the only product which is expected to witness a slight increase medium-term. This fact is supported by the upcoming IMO regulations and the general shift towards diesel as a fuel for light duty vehicles. Residual fuel oil is expected to be replaced in the future by LNG and demand for naphtha is projected to be limited during the forecast period.

Future ethane/LPG demand in the region is likely to increase in the next 10–15 years, before declining, though the level of initial expansion is uncertain. Within this product group, ethane use will increase as new petrochemical projects absorb additional barrels, while LPG is expected to extend its declining trend. The net effect

of these trends means that overall demand is expected to be marginally lower by 2035, at 2.5 mb/d, compared to that observed in 2012[49].

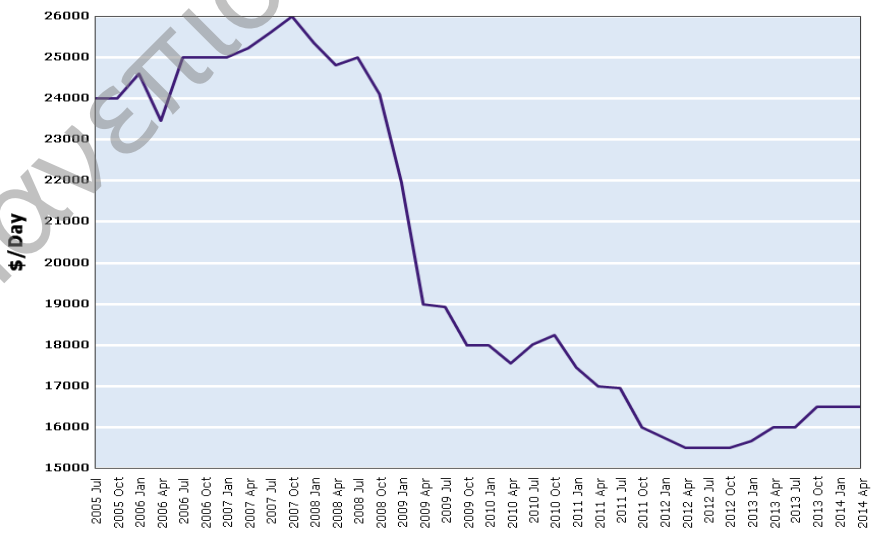
As far as the time charter rates for product tankers they are currently at low levels but generally higher compared to the levels of 2012. Time charter rates for product tankers follow the same pattern of crude oil time charter rates. Product market is inevitably affected by the crude oil market, since the latter is the main source of refined products.

Figure 4.11: 1 Year Time Charter 74.000 dwt Modern Products Tanker



Source: Clarksons Research Services Unlimited

Figure 4.12: 5 Year Time Charter 74.000 dwt Modern Products Tanker



Source: Clarksons Research Services Unlimited

The orderbook of product tankers included by the beginning of 2014 approximately 75 Aframax vessels and something more than 9.000.000 dwt. This is

an obvious rise in ordering compared to approximately 12 Aframax vessels that were in the orderbook the previous year. As far as the deliveries of product tankers by May 2014 seem to be reduced by 50% compared to the deliveries that occurred in 2012, while the demolitions of Handysize product tankers as per May 2014 accounted for two, significantly less than the demolitions that took place in the end of 2013. Demolitions of Panamax product tankers accounted as per May 2014 for only one. Product tanker freight rates are expected to rise due to the upcoming demand for petroleum products especially in non OECD countries. Additionally the fleet growth, which peaked between year 2007 and 2008, starts to shrink year by year. This annual shrinking of the product tanker fleet will certainly influence the product market; charter rates are set to improve while the transport work of vessels is projected to increase, mainly in the Asia-Pacific region.

CONCLUSIONS

The last five years have been really tough for the shipping industry. The world economic recession had undoubtedly a negative impact on the shipping sector. Financing through the banking system is very rare and most projects remain unfunded. Still there are some indicators, which forecast a better future for the shipping industry such as the rise of the World GDP. The rising energy demand globally indicates a world trade rise. The emerging Asian economies are expected to be the major players to the world trade. The use of alternative sources of energy and the replacement of others changes the energy trade market. LNG mainly and diesel are projected to be the fuels that are going to be used in the future both in industrial and transportation sector. The rise of LNG has been tremendous the last years and the charter rates for LNG carriers are projected to rise due to the rising demand for this fuel. The LNG shipping market is a bordered market. The high initial cost for building or buying an LNG carrier is extremely deterrent, especially in periods when cash flow is inadequate. However the future for the LNG market is expected very profitable. As far as refined products, diesel oil will certainly replace gasoline in the transportation sector long-term and the rise of it is going to take place mainly in Asia-Pacific region where the largest refinery facilities are located.

FINAL CONCLUSIONS

- The regulatory framework related to LNG production and trade has become more flexible the past decade, giving the opportunity to gas related companies and traders to formulate new terms of buying and selling natural gas in an integrated global market.
- LNG trade via pipelines is mainly met in mature markets such as U.S.A. it is not a coincidence that four out of the eleven longest pipelines serve the North American market.
- LNG trade is projected to increase sharply in the Asia-Pacific market, mainly in China and India, and even long-term LNG trade via pipelines is expected to boom, if any investments in LNG pipelines infrastructure take place.
- The most important LNG exporter is globally and is projected to be Qatar, while Malaysia is the second globally most important and simultaneously the largest in the Asian market followed by Australia and Indonesia. Nigeria is also an important player in the global LNG market, being the largest African exporter.
- As far as oil trade, China is projected to surpass U.S.A. in oil imports in the following years.
- Russia's Eastern Siberian oil fields are a significant source for Chinese crude oil imports either through pipelines or oil terminals located in Russia's Far East like De-Kastri and Prigorodnoye terminal. China's crude oil imports through sea trade are expected to increase, due to the fact that oil transfers through sea trade long distances (Middle East-China) are the most cost-efficient.
- Consequently the traffic in South-East Asia region is projected to increase, a fact that will result in an increase of traffic and in the Middle East as well (Suez Canal, Red Sea, Persian Gulf and Arabian Sea). An increase in Suez navigation will induce an increase in navigation in the Mediterranean Sea.
- India with its year to year increased oil imports through sea trade and the country's lack in pipeline infrastructure has contributed in the increase in traffic in the South-East Asia region.
- Crude oil imports via sea trade to U.S.A. rely mainly on the main Passages from Middle East through the Suez Canal, from Middle East through the Cape of Good Hope or from North Sea and Latin America and West Africa through Atlantic Ocean.
- U.S.A.'s crude oil imports from Canadian oil sands are solely made through pipeline network and through the completion of the Keystone XL Pipeline by 2015 the oil imports are projected to increase by 830.000 b/d, half of what currently U.S.A. imports from the Persian Gulf.
- Nigerian and Brazilian oil exports seem to contribute in the increase of the Atlantic oil Routes.
- As far as the refined product flows great changes seem to take place. The shift in the refining sector from West to East is obvious.

- The 2007 economic recession was a determinant factor to this shift.
- Many refineries since 2008 in Europe have shut down or have reduced their production while many refineries in the U.S.A. started to have access to more economic feasible crude oil sources such as the Canadian oil sands and the Bakken Province.
- Demand for middle distillates is projected to increase in Middle East
- On the contrary demand for gasoline in North America and Europe is projected to continue to decrease due to environmental regulations and to the shift towards more eco-friendly fuels such as diesel oil.
- China's demand for motor gasoline is growing rapidly day by day due to the country's tremendously expanding car fleet which is projected to reach 266 million cars by 2025. Due to the country's vast energy demand for refined products, authorities plan to expand the country's refining capacity to 2.4 mb/d by 2018.
- The rising energy demand globally and the rise of world GDP are indicators of the trade growth. The emerging Asian markets are projected to be the major players to the world energy trade.
- The two dominant fuels of future both in transportation and industrial sector are expected to be LNG and diesel.
- The increasing demand for LNG is expected to result in an increase in charter rates of LNG carriers and in their tm.
- The order-book of LNG carriers and more specifically the scheduled delivery of the vessels is a determinant factor, which will certainly affect the future charter rates.
- Long-term diesel oil is projected to replace motor gasoline in the transportation sector.
- Investments in oil refining industry mainly in the Asia-Pacific region will affect the product tanker charter rates.
- Easier financing via the banking system in the future will help ship-owners fund their business plans.

BIBLIOGRAPHY AND REFERENCES

1) http://www.ch-iv.com/lng_information .html (visited May 10, 2014)

2) http://www.shell.com/global/future-energy/natural-gas/liquefied-natural-gas/what-is-lng.html (visited May 10, 2014)

3) International Gas Union Report 2014 a p.7, http://www.igu.org/gas-knowhow/publications/igu-publications/igu-world-lng-report-2014-edition.pdf (visited May 10, 2014)

4) International Gas Union Report b 2014 p.9, http://www.igu.org/gas-knowhow/publications/igu-publications/igu-world-lng-report-2014-edition.pdf (visited May 10, 2014)

5) The Age of Gas & the Power of Networks a Peter C. Evans & Michael F. Farina, p.28-29

6) The Age of Gas & the Power of Networks b Peter C. Evans & Michael F. Farina, p. 29

7) 8) : http://www.liquefiedgascarrier.com/Liquefied-Natural-Gas-Carriers.html A, B (visited May 13, 2014)

9) The Age of Gas & the Power of Networks C Peter C. Evans & Michael F. Farina, p.30

10) CNG vs LNG http://www.neptunegas.ca/marine_cng/alternatives.html (visited May 14,2014)

11) Gas Geopolitics A: Visions to 2040, Amy M. Jaffe, Mark H. Hayes & David G. Victor (Revised August), p.5 (visited May 16, 2014)

12) Gas Geopolitics B: Visions to 2040, Amy M. Jaffe, Mark H. Hayes & David G. Victor (Revised August), p.6 (visited May 16, 2014)

13) Role of Stranded Gas in Increasing Global Gas Supplies by Emil D. Attanasi and Philip A. Freeman
Open-File Report 2013–1044 U.S., p.3 (visited May 16, 2014)

14) China Starts Work on $20B Pipeline for Turkmen Gas
http://www.downstreamtoday.com/news/article.aspx?a_id=8868 (visited May 17, 2014)

15) Briefing on the West-East Pipeline Project by Xie Geguo

16) China starts work on 3rd West-East gas pipeline (article)http://www.reuters.com/article/2012/10/16/china-gas-pipeline-idUSL3E8LF5E220121016 (visited May 18, 2014)

17) http://www.gazprom.com/about/production/projects/pipelines/yamal-evropa/ (visited May 18, 2014)

18) http://www.hydrocarbons-technology.com/projects/trans-med-pipeline/ (visited May 19, 2014)

19) http://www.northernborder.com/Default.aspx (visited May 19, 2014)

20) James Henderson, The Potential Impact Of North American LNG Exports, October 2012, p. 9

21) http://www.shell.com/global/aboutshell/major-projects-2/qatargas.html (visited May 21, 2014)

22) http://oilprice.com/Energy/Crude-Oil/What-Is-Crude-Oil-A-Detailed-Explanation-On-This-Essential-Fossil-Fuel.html (visited May 28, 2014)

23) http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/natural-gas/advanced-drilling.aspx (visited May 28, 2014)

24) http://nesteoil.com/default.asp?path=1,41,538,2035,5196,5197,5199 (visited May 29, 2014)

25) International Energy Agency A, Oil Market Report, p.5, 11 December 2013

26) International Energy Agency B, Oil Market Report, p.10, 11 December 2013

27) Data from http://www.eia.gov/countries/index.cfm?topL=exp A (visited May 30, 2014)

28) http://www.eia.gov/countries/country-data.cfm?fips=CA B (visited May 31, 2014)

29) http://www.energy.alberta.ca/oilsands/793.asp (visited May 31, 2014)

30) http://www.eia.gov/countries/country-data.cfm?fips=CA C (visited May 31, 2014)

31) http://www.maritime-executive.com/magazine/CrudebyBarge-2013-10-15/ (visited June 2, 2014)

32) The Oil Network in U.S.: A Closer Look at Pipelines, Tyler Carter-Mike Pescatore A, 12/13/2006, p.5

33) Crude Oil Forecast, Markets & Transportation, Canadian Association of Petroleum Producers, p.29

34) The Oil Network in U.S.: A Closer Look at Pipelines, Tyler Carter-Mike Pescatore B, 12/13/2006, p.5

35) http://www.eia.gov/countries/regions-topics.cfm?fips=wotc&trk=p3 D (visited 4 June 2014)

36) http://www.eia.gov/countries/regions-topics.cfm?fips=wotc&trk=p3 E (visited 4 June 2014)

37) http://www.eia.gov/countries/cab.cfm?fips=kz F (visited June 4, 2014)

38) http://www.eia.gov/countries/cab.cfm?fips=KZ G (visited June 4, 2014)

39) http://www.shell.com/src/about-src/refining-process.html (visited June 12, 2014)

40) Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal A, October 2010, p.6

41) Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal B, October 2010, p.8

42) Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal C, October 2010, p.10

43) Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal D, October 2010, p.12

44) Poten & Partners 2015-2035 LNG Market Assessment Outlook for the Kitimat LNG Terminal E, October 2010, p.14

45) World Oil Outlook 2013 A, OPEC, p.60

46) World Oil Outlook 2013 B, p. 190

47) World Oil Outlook 2013 C, p. 191

48) World Oil Outlook 2013, p. 194

49) World Oil Outlook 2013, p. 194