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A global perspective of Liquefied Natural Gas vessels capacity.

by

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Abstract

Today we live in a globalized economy, dominated by series of domino effects and contagious phenomena, a situation that renders the business decisions hard to be made. The significant growth in world energy demand has incited an intense phase of capital accumulation in shipping sector and Liquefied Natural Gas (LNG) sea transport in particular. The fast-paced developments attracted the author's interest to deepen the research of this specific market.

The following dissertation analyzes the current market of LNG tankers through both theoretical and quantitative approaches. The author aims to identify the main factors which determine the global tonnage of LNG fleet. In order to archive that, information available from the public domain, academic curriculum and literature have been used. In addition a research model has been derived, and the regression analysis has been applied in favor of vessels capacity prediction in a given time.

Natural gas used to be a rejected product of oil production, these days it is a major source of energy. Liquefied Natural Gas (LNG) used to be considered an expensive method of commodity's transportation but current costs and the short-term predictions seem to diminish the concern of high expenditure, due to the infrastructure already constructed and that is being built.

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List of Abbreviations

BBL: Barrel (unit) 158.9873 Litres Equivalent (or 42 US gallons)

BCF: Volume (unit) Billion Cubic Feet

EIA: U.S. Energy Information Administration

FLNG: Floating, Liquefied Natural Gas (Platform)

FPSO: Floating Production, Storage and Offloading (Platform)

LNG: Liquefied Natural Gas

MCF: Volume (unit) Thousand Cubic Feet

MMBTU: Thermal (unit), Million British Thermal Units

MTPA: Million Tonnes per Annum

OECD: Organization for Economic Co-operation and Development

STP: Standard Temperature and Pressure Conditions

TCF: Volume (unit) Trillion Cubic Feet

TONNES: Mass (unit) Metric Ton Equivalent to 1,000 KG

WTI: West Texas Intermediate (grade of crude oil)

1. Introduction

1.1 Outline of the Study

The following thesis was prepared in the requirement of the Maritime Economics and Logistics master's degree of Erasmus University Rotterdam. The work for this study was carried out during the summer of 2013 in Rotterdam, The Netherlands. As a main purpose, this thesis has been conducted in order to develop a forecasting model of the total tonnage of LNG fleet worldwide using the major variables which influence the supply and demand for Natural Gas sea transport.

Natural Gas, for over half decade ago, had been mostly a product rejected from oil production. After the oil crisis of 70's the importance of natural gas as a heating and electricity resource of energy boosted the value of that formerly rejected commodity. The Liquefied Natural Gas (LNG) is natural gas which has been transformed into liquid state via a cooling process. This method has been used especially for natural gas transportation as its liquid form occupies relatively less volume. The infrastructure for LNG sea transportation is becoming highly important in the energy trade worldwide as major economics, such as Japan, lacking natural resources and as a result have been investing in infrastructure or importing the commodity via sea. LNG vessels, with ever increasing tonnage and high technology systems onboard, transfer the valuable commodity all over the globe.

The market for LNG sea trade is estimated to be one of the main growth areas for the global fleet over the short to medium-term. The shale gas growth in United States, has reduced the country's imports in comparison of the earlier forecastings, but is likely to result in natural gas export volumes. On the other hand, environmental regulations and emissions policies may lead to a growing role for gas as a resource of energy in several sectors such as the electricity generation. The rapid growth of the Asian markets is also expected to boost the LNG trade via sea. Without any doubt, the author understand the possible weakness following the proposed project, as it wasn't possible to quantify major non-numerical factors such as weather conditions, wars and market psychology. Despite that lack of data, there is a strong belief that the applied methodology would be a potential tool for individuals in order to have an indication of the market in time given.

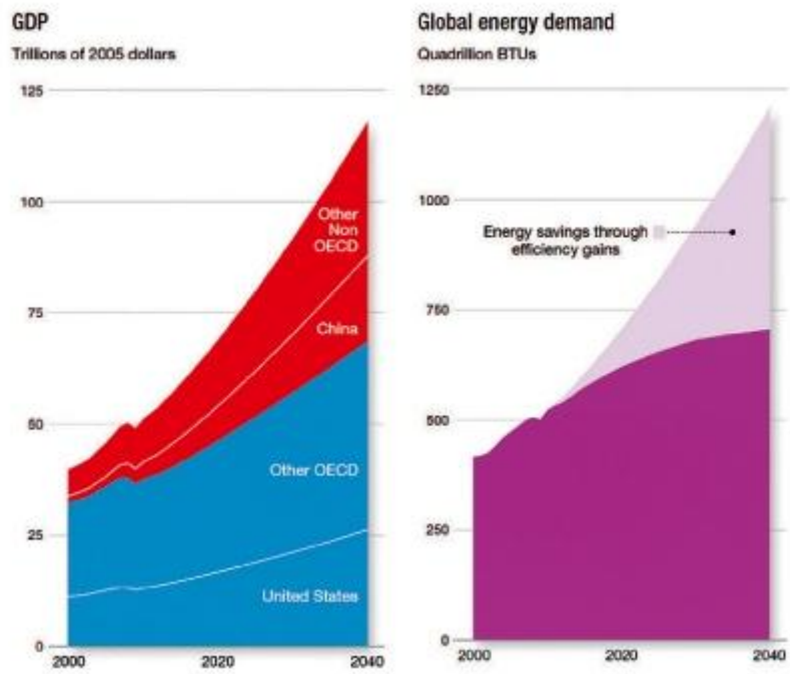
The current capacity of LNG fleet in combination with the existing demand could illustrate a trend of the freight rates and be useful for investment decisions.

In attempt to answer the principle research question of LNG fleet capacity determinants, the thesis is composed of 4 chapters. As an indication, firstly there is an introductory chapter which presents the outline of the study and the directions of energy and sea transport. The second chapter illustrates the whole empirical overview of the LNG market. Several factors which determine the LNG vessels capacity have been identified. The third chapter introduces the related Methods and Methodologies while formulates the appropriate research model following by different hypotheses. Finally, the fourth part presents the regression analysis process; the derived results and findings as well as the validity of the used model. An extensive discussion and conclusion section completes this study including the Market's outlook and some general evaluations and suggestions.

1.2 Increasing Energy Demand

Clearly, the availability of energy resources has become crucial these days, while the depletion's rate has surpassed the rate of new discovered energy resources. At the same time the globally, increasing demand drives natural gas prices up. Although the economic recovery these days is witnessing a slow-down, defiantly does not mean that there is no considerable growth and demand coming the following years.

According to [Figure 1], the global energy demand will grow 35 percent even with important efficiency improvements, as the world's population will increase from 7 billion today to approximately 9 billion people by the 2040, mainly led by the growth in Africa and India. With this growth comes a surge for electricity demand which is the largest driver of energy demand.



[Figure 1] Increasing Energy Demand: Global GDP and Energy Demand from 2010 to 2040

The global economy is expected to recover and grow at an annual average rate of 2.8 percent to 2040. This economic growth and improved standards of living will require more energy. The economic expand with relatively low growth rates is mainly coming from energy efficiency improvements across all sectors as well as the transforming of China from an energy-intensive manufacturing country to a consumer-focused with less energy requirements per GDP/capita.

The correlation among population growth, energy demand and GDP development is clear. What is under question is how the sustainability growth of nonrenewable industry will be achieved. Thus, it is very reasonable to see drilling technologies to be fully utilized recovering every possible reserve with maximum efficiency of materials and energy used for the extraction.

The boundary line between oil and gas reserves and resources is highly related on both domestic economic factors and those of global market. The price is the key point in extracting and providing the commodity. Hence, accurate economic forecasting models remains a core issue in successfully planning and implementing projects as well as supplying commodities such as natural gas to the world market.

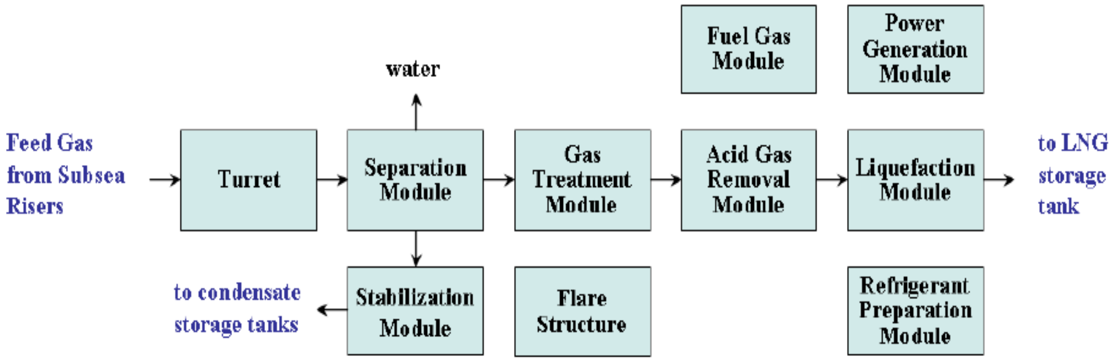
1.3 Natural Gas, LNG and Shale

Natural Gas, The decomposition of organic matter in an environment that lacks the presence of oxygen, with the assistance of anaerobic bacteria, results in the formation of methane gas (Riva 1983)

Natural gas is a mixture of light hydrocarbons, predominantly methane. Around three-quarters of the world's natural gas is found separate from crude oil ('non-associated'); the rest is found in association with crude oil ('associated gas'). The main applications of natural gas are in the residential, commercial and industrial heating sectors and as a fuel for power generation. It is also used as a feedstock in the petrochemicals industry, in the manufacture of ammonia for fertilizers and in the production of gasoline, methanol and middle distillates." (Majid 1992)

The use of natural gas mainly has a dual purpose. It has been used to generate electricity and heat as well as transport fuel. In addition there are many cases of natural gas use from industry usually for the production of plastic, chemical or even pharmaceuticals.

Liquefied natural gas (LNG) is natural gas in liquid state after a process of temperature decrease and pressure increase. With a temperature of -161degrees Celsius, the volume of gas is brought down.



[Figure 2] Natural Gas, LNG and Shale: Typical LNG Liquefaction Process

The technic of liquefying natural gas into LNG [Figure 2] is mainly based on 4 steps: Firstly impurities such us carbon dioxide are removed from natural gas, then the moisture is removed to avoid water crystallization during the cooling process, a phenomenon that can be dangerous for the equipment. After the removal of impurity and moisture, heavier hydrocarbons are removed. The dried gas is gradually cooled through a cycle refrigeration process to –161 degrees centigrade and stored into cryogenic tanks.

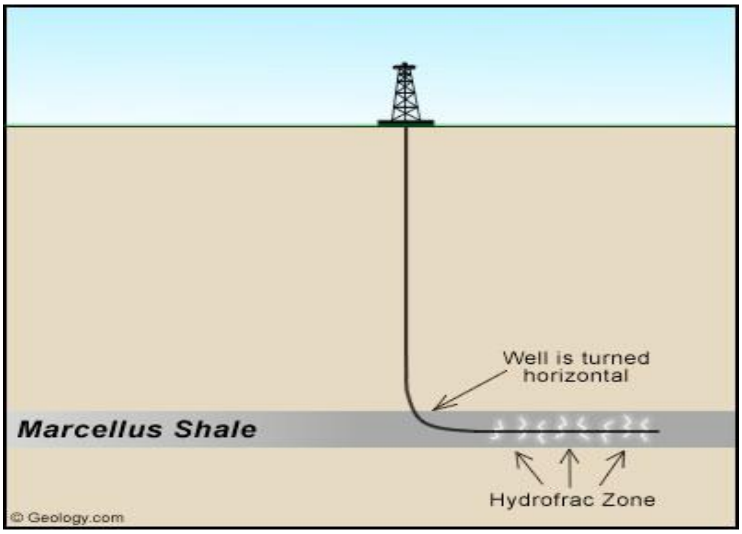
At this form, the natural gas is mainly constituted of methane and ethane, occupying 600 times less the initial standard temperature & pressure (STP) volume. Thus, the stored energy is becoming sufficient to be transported and profitably sold.

Regarding the different economic and technological availability, natural gas can be transported with several mediums such us pipelines and ships. Pipeline transit does not require significant additional processes; on the other hand transportation in tanks, either via sea or land, requires the natural gas to be in liquefied form.

The last 8 years, significant developments in the shale gas extraction have been generated a dynamic shift in natural gas markets. Shale gas is a natural gas trapped in fine-grained sedimentary rock called shale. (McGlad 2012 12)

Shale gas was always present but the extraction methods were not economically feasible. New techniques such as horizontal drilling and hydraulic fracturing changed the dynamics. All that newly economic viability, made even more supply available in lower costs. (Katz 2010)

As already mentioned, horizontal drilling in particular is one of the key-factors that made shale gas economically feasible. As the thickness of the pay zone is usually insufficient, horizontal wells are drilled within each shale layer [Figure 3]. Except for some special tools used underground, the horizontal drilling requires the same equipment and technology as the vertical. (Worldwatch Institute 2010)



[Figure3] Natural gas, LNG and Shale: Horizontal gas well.

Another very useful method of shale gas extraction is the hydraulic fracturing or *fracking*. It's a process which is used to create fractured in the rocks and as a result to allow the trapped natural gas move to the wellbore.

The International Energy Agency (IEA) has estimated that under the right conditions, unconventional gas might cover more than 40% of the increased global demand for gas by the 2035. However, many questions still remain about how easily unconventi onal gas resources can be developed outside North America. By this time, the production of shale gas is still overwhelmingly characteristic of The United States and Canada. In the light of that North American phenomenon and with evidence of declined resource base, it has been an increased interest from many countries in improving their energy supply safety and gaining economic profits from the exploration of their shale gas reservoirs. However, the successful shale gas recourse development in countries with such a potential based in few key-factors including: the access to geological data on a transparent basis, the regulatory frame and fiscal conditions, availability of knowhow and sufficient market pricing.

The LNG market is facing the problem that the actual extent of shale gas reserves is still unknown. Large reserves of shale gas, potentially could have adversely affect the current dynamics within the LNG industry. (Global LNG trade & Trends 2030 2013)

In addition to shale gas developments, there is focus on offshore exploration with big market leaders constructing Floating Production, Storage and Offloading (FPSO) platforms with a much riding of success. Also LNG, as bunker fuel, is coming on the top of shipping agenda in light of high bunker prices and environmental regulations. Whatever is the future of natural gas market, the next years will be instrumental for this niche sector.

1.4 The Shipping Market

The global economy, mainly through the industrial activities, produces goods which require to be transported via ships. The trends in particular sectors can potentially influence the general pattern of demand, for instance a change on natural gas price could lead to changes on sea transport demand of the commodity. In addition, possible variations of the distance that a cargo must be transported have as a result the change of the final sea transport demand calculated in ton-miles. The measurement in ton-miles is technically more accurate than in deadweight tons of the vessels under operation as it takes into consideration the efficiency of ships employment. (Collins 2000 87)

[Figure 4] The shipping market: Demand and Supply (Source: Shipping Economics and Policy Mel Handbook)

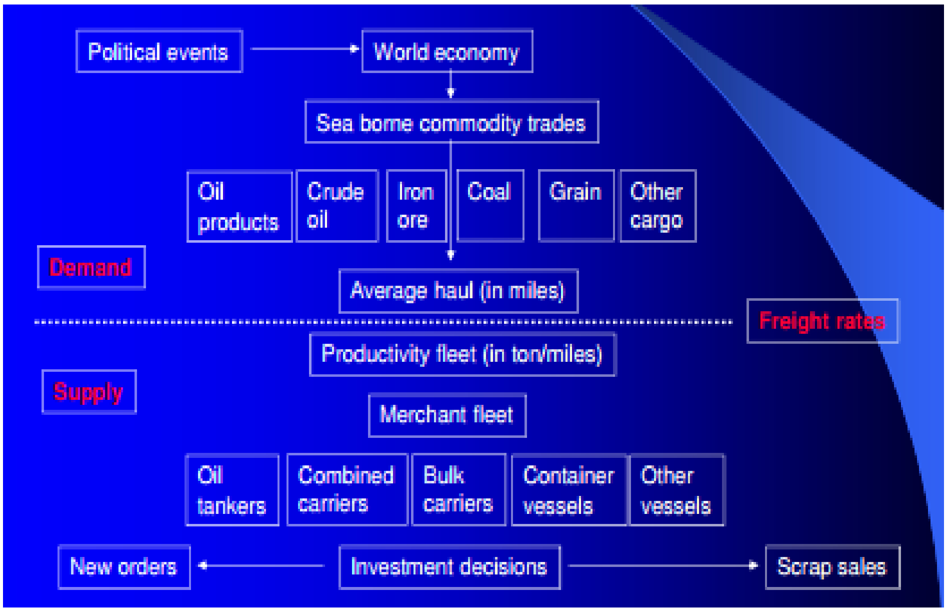
Based on the [Figure 4] above, from the side of demand for sea transport there are five (5) main variables: the world economy, the seaborne commodity trades, the average haul the political events (exogenous factors) and last but not least the transport cost.

Accordantly, the supply of sea transport is related to six (6) major factors: the world fleet, the fleet productivity, the shipbuilding production, the scrapping and the freight rates.

In short-term the merchant fleet represents the constant transport capability. Yet in long-term, based on business decisions from shipping companies it is likely only a part of that fleet to continue operate as a transport mode. Some vessels could laid-up or transform into storage platforms (FSO).

Generally speaking, the word fleet can be increased from new shipbuilding projects as well as to be decreased from scrapping. (Collins 2000 83-85)

The following [Figure 5] represents the general idea of how all those determinants embodied to shipping market.



[Figure 5] The Shipping Market: An Integrated Model. (Source: Shipping Economics and Policy Mel Handbook)

A very critical part of shipping market model is the freight rates which practically connects supply to demand for sea transport. When there is a deficit of vessels supply the freight rates increase and the ship owners have strong negotiation power in the market. The cash flows which end up at ship owner's bank accounts could influence the behavior of the other market players such as the charters or port operators as well as the ship owners themselves who often invest that money to new buildings. On the other hand, when there is surplus of available vessels, the freight rates decreasing and the ship owners in many cases struggle to cover the ship's operating costs. Thus they turn to sell some vessels in order to gain the necessary funds. The price of vessels decrease and the scrapping agencies offer relatively high prices in order to attract additional tonnage for demolition. Furthermore the low freight rates change the performance of the fleet mainly from speed adjusting (lower speed) or laid-ups.

Eventually the balance in the market and the freight rate levels are the most important economic facts of the market model and is related to the business decisions from the ship-owners, as well as the general psychology of the market players. Hence, as the behavioral aspect is critical for the market trends, it is almost impossible to have an accurate simulation using mathematical forecasting models. The general shipping model as it is presented before illustrates how complex the shipping market is. The demand for sea transport is volatile, and adjusts very quickly in the global economics changes. In contrast the supply is maladaptive to changes on demand. As Martin Stopford mentioned, «The supply is like a turtle who tries to catch the rapid which is the demand» (Stopford 1988 36-84)

Based on the above, it can be concluded that the short term changes on freight rates are resulting from the demand as the supply of sea transport is inelastic in the short term. (Metaxas 1971 197)

The most important determinant of sea transport demand is the global economy. It has been calculated that the 80-85% of world trade in terms of cargo transported is executed via sea. It is also proven that the fluctuations in shipping market follow the general pattern of the economy's cycles. It is an expected outcome as the demand for sea transport is derived demand, coming from the world economy and sea trade. (McConville 1999 35-36)

The circles of shipping market, exactly as those of economy, are coming from the combination of endogenous and exogenous factors. The analysis of shipping circles, a very interesting and complex topic, it could be a separate thesis topic itself. Hence the author just aims to notice the existence of those factors such as: weather (physical phenomena), political and socioeconomic events, technological improvements, wars, etc. It is obvious that a complete study of shipping market must include all those important exogenous events. Yet, it is very difficult for the researchers to translate those phenomena into economic terms and use them into an integrated forecasting model.

Equally important to note, the sea transport demand is influenced from the sea trade and the related sea routes. In short term, the seasonality of some cargos is related to ships demand fluctuations. On the other hand, in long-term, factors such as the changes on cargo demand, differentiation of import-export locations, industry locations and charters policy could influence the demand for sea transport. Additionally, the demand for sea transport is depending also from the distance that the cargo must be transported. The variable which referring to that distance is known as average haul and is calculated in ton-miles which is the tonnage of transported cargo multiplied from the average required distance. (McConville 1999 35)

The impact of average haul has been appeared many times before. For instance several times during the last decades when the Suez canal was closing, the distance between middle east and Europe almost doubled leading to higher freight rates especially for oil tankers. Moreover, the supply of vessels is depending generally from 4 decision making lobbies: ship-owners, charters, banks and regulatory organizations. The ship-owners take the decisive decisions, as they choose when to place an order to yards for new buildings or when to scrap an older vessel. Also, the regulations and legislation influence the supply for sea transport. For instance, Marpol rule of 2003 promoted the phase-out of single hull tankers. In addition, the total transportation capability which is provided from the global fleet is depending on the fleet productivity which includes factors such as: vessels speed, total covered distance and time sailing with ballast.

1.5 Direction towards Sea Transport

«**History made as LNG fleet hits magic 500 mark»**

«*The number of ships has doubled in the last 10 years but the composition is more diverse, with the main boost coming from the entry into service of a range of new liquefaction projects*. » (Tradewinds.com 26 June 2013)

«SHI Enters $892 Mln Shipbuilding Contract with Nigeria LNG»

«Samsung Heavy Industries announced on Thursday that the company has entered into a shipbuilding contract with Nigeria's Bonny Gas Transport for the construction of four LNG carriers. The contract is estimated to be worth around $892 million'. » (shipbuildingtribune.com 4 April 2013)

«Japan: LNG Imports Rise 4.4 Percent in 2012/13»

«Japan's LNG imports reached 86.865 million tons in the fiscal year that ended in March, up 4.4 percent compared to the same period before, according to trading data. » (lngworldnews.com 18 April 2013)

«Greeks dominate in orders for new LNG carriers»

«The LNG carrier market is a very promising one as consumption of this form of fuel has been rising rapidly in recent years. Shipping analysts say that this section of the market is showing significant growth thanks to the discovery of new reserves in Africa and Australia, which is threatening the monopolies of the traditional oil and natural gas powers in the Middle East and in Europe. »

*«Eight Greek ship-owners have spent $7.4 billion on orders for 38 such vessels, accounting for almost half of all global orders. » (*ekathimerini.com 18 October 2012)

Obviously, we experience an intense phase of capital accumulation in LNG industry. This capital intensive market of sea transport is strongly depended on other activities such as exploration, refineries, pipeline network etc.

The sea transport of LNG, similarly to other cargo transits by the sea, is determined form supply and demand. The supply of tonnage and the demand for sea transport are the two pillars composed from a series of sub-elements. Thus, the interaction of supply and demand set the market for that particular trade.

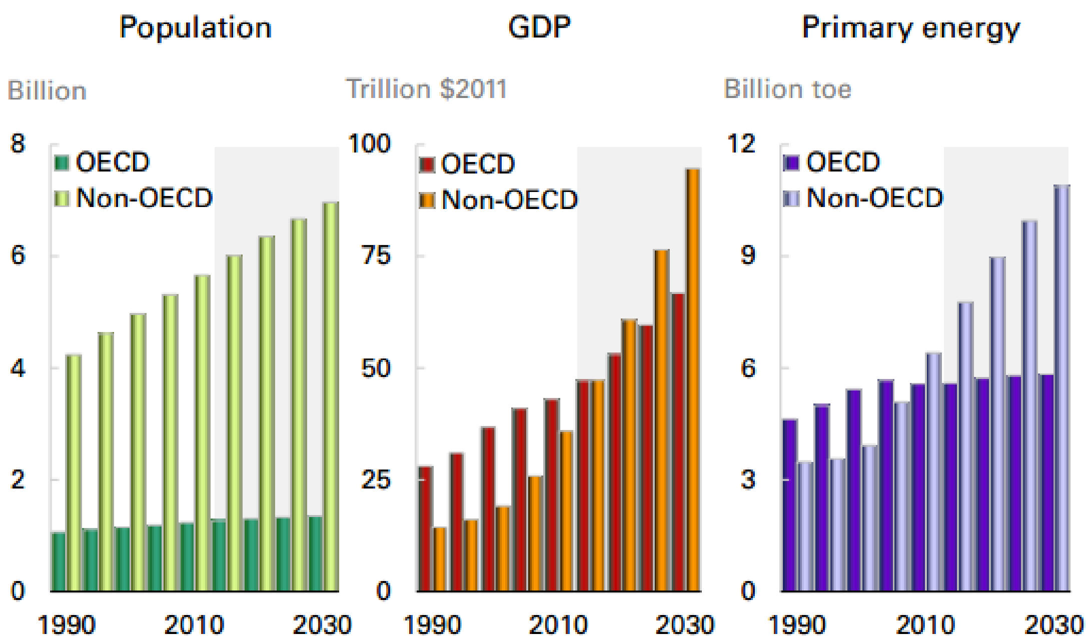
Looking at the forecasts, there will be another 2 billion tons of cargo transported by tankers in 2025. The OECD region is now economically mature so it is growing quite slowly. As Asia and China in particular grow, the importance of the ring of economies around the South China Sea will increase. India is on the road to deregulation and is growing fast. With luck over the next twenty five years the ex-Soviet states will overcome their present difficulties and become a more substantial economic force. Latin America is growing steadily and with each decade will gain critical mass as a center of trade. (Stopford 2000)

The forecasts for LNG market are very positive as the demand is expected to surge the following years. New pipeline networks and import-export terminals boost the sea transit of the commodity. Even if, mostly in Europe, all the potential pipelines will be constructed its almost sure that still will be demand to be covered from LNG vessels. Moreover regarding the Asian market (South Korea, Japan) where there is no possibility for imports via pipelines, the operation of LNG fleet will be massively increased.

2. Empirical Overview of LNG Market

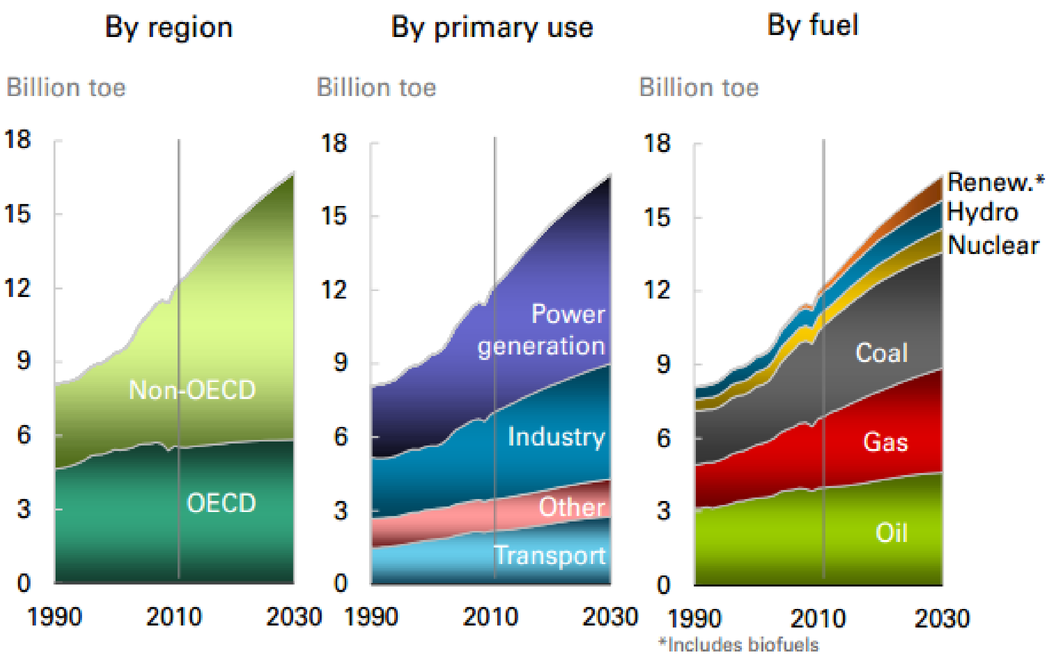
2.1 Natural Resources Overview

Still these days the fossil fuels are the dominant chemical source of energy. In effort to keep simplicity, the fossil fuels are referring to crude oil and natural gas formations.



[Figure 6] Natural Resources Overview: Population and Income Growth (source: ExxonMobil)

Based on the [Figure 6], the population and income growth are leading to increasing energy demand. World population is expected to reach 8.3 billion by 2030, which means more than 1 billion people will have the need of energy. The global income for the same period is projected to be double the amount of 2011 in real terms. With average rate of 1.6% per year, the world primary energy is expected to surge the global consumption up to 36%



[Figure 7] Natural Resources Overview: Energy by fuel and by primary use. (ExxonMobil)

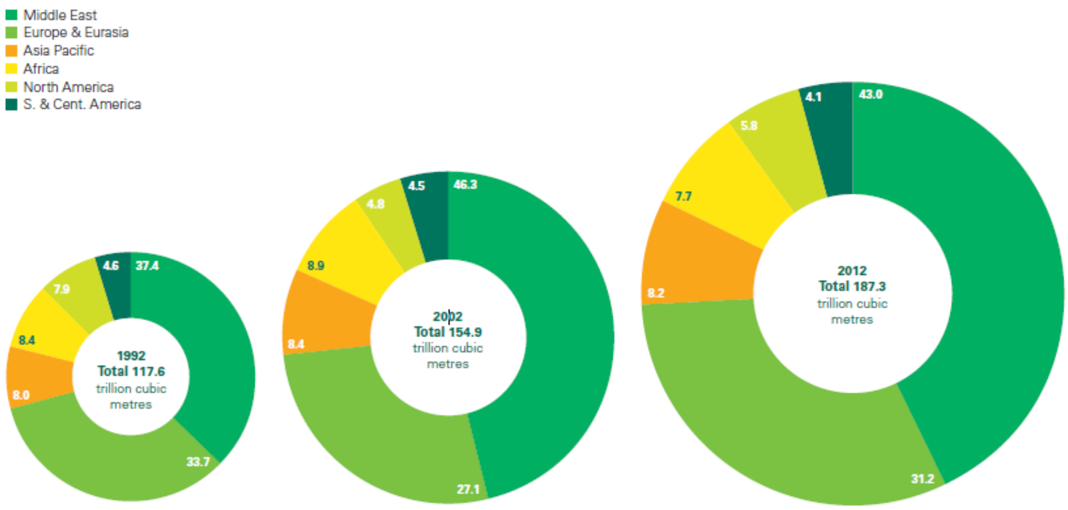
The energy consumption increase is mainly driven from non-OECD nations. Energy used for power generation, with major component the electricity production, grows by 49% at 2030. Indeed the fossil fuels still dominate the energy resources field with natural gas grows the fastest among them [Figure 7].

With the emission restrictions to be increasingly strict and expectations of possible crude oil depletion in some decades, it can be assumed that the oil age is in an transitory era. Until then the race to discover new energy resources will remain a hot topic, particularly when the existing reserves will start falling to meet the increasing demand.

2.2 Natural Gas Accumulations

Natural gas accumulations are found in few different settings. Yet, the conventional gas appears either above the crude oil accumulation or as gas dissolved into oil accumulations.

According to BP's Statistical Review of World Energy for 2013, the total natural gas proved reserves by the end of 2012 accounts of 6614.1 trillion cf. the following figure shows the distribution of those reserves with Middle East be the dominant as it holds the greater of those reserves.

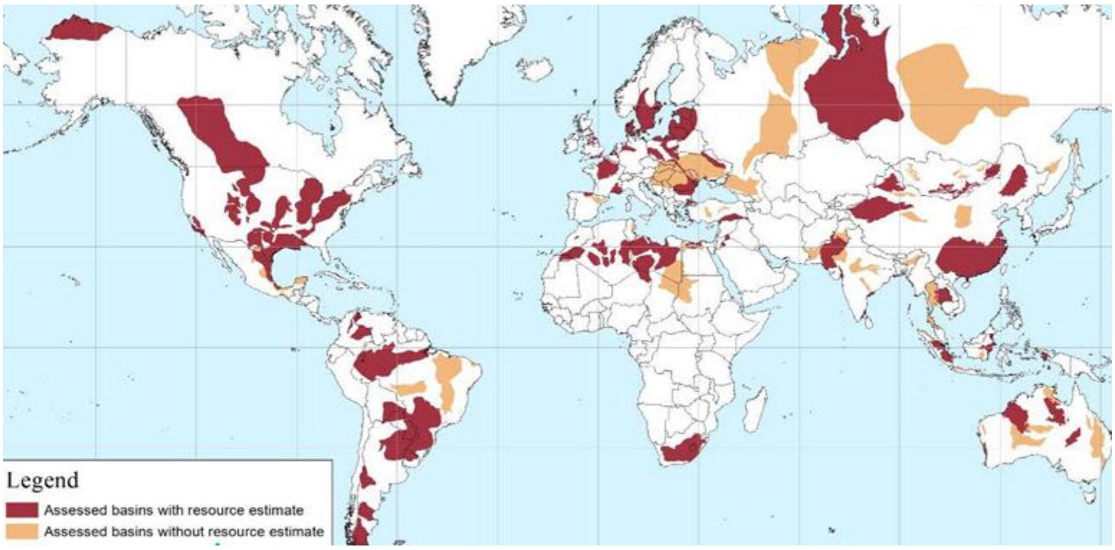


[Figure 8] Natural Gas Accumulations: Distribution of proved reserves in 1992, 2002, 2012 (source: BP Statistical Review of World Energy June 2013)

Despite the given proven gas accumulations there is a differentiation between reserves and resources [Figure 8] mainly because of the extraction cost among the regions as well as the rate of consumption and new discoveries.

[Figure 9] Natural Gas Accumulations: Reserves to Production (source: BP Statistical Review of World Energy June 2013)

It is very important to stress that lately shale gas coming on the global energy scene. According to EIA the technically recoverable shale gas resources accounts approximately 7,795 trillion cubic feet [Figure 9]. Technically recoverable resource refers to the amount of natural gas that could be drilled with the current technology and regardless production costs and market prices. Thus the expansion of shale gas developments the following years is very critical to move from technically recoverable to economically recoverable gas which represents the profitable recovery of the commodity.



[Figure 10] Natural Gas Accumulations: Basins with assessed shale gas formations as May 2013 (sourse: EIA)

2.2 Natural Gas consumption factors.

According to US Energy Information Administration 2013, the demand for natural gas is influences from:

- The global GDP
- The Oil prices
- The weather conditions

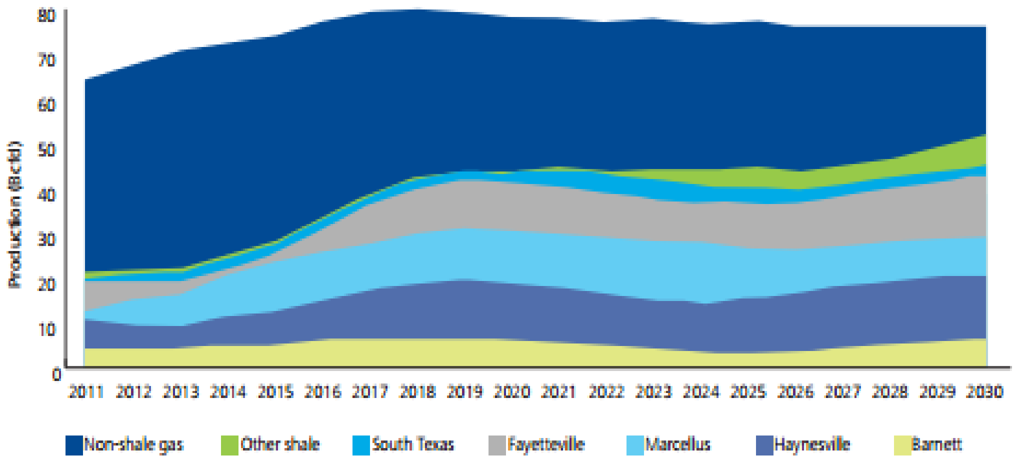
Similarly, the supply of the precious commodity is determined from:

- The Natural Gas production levels
- Imports and Exports volumes
- The stored volumes

Based on the above, the world development expressed by the GDP influences the demand for Natural gas, as it's related to the prices of substitute energy resources (oil). From the empirical perspective it seems that whenever oil prices goes up the demand for natural gas also increases.

Regarding the relationship between oil and natural gas price, the most of the sales contracts in Europe are based on crude oil prices (Ramberg 2010). In Asia the Japanese Customs Clearing Prices (JCC) Index is been used to illustrate the price of LNG contracts.

Without question, the supply of natural gas in North America has changed dramatically by the growing development of shale gas [Figure 11]. Before that technological improvements leading to current shale production, the main interest of the North American market, which includes United States and Canada, was the construction of LNG import facilities as the natural gas was merging as significant source of energy. By the first years of 2000 a great number of regasification terminals were ready to be built but the incredible surge of shale gas production changed that expectations. Indeed as is shown in figure the forecasted shale gas production projects to grow and finally become the main component of US natural gas supply.

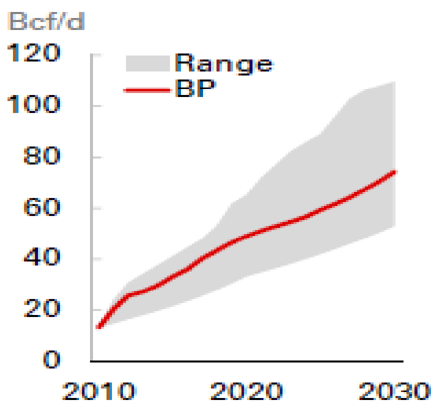


[Figure 11] Natural Gas Consumption Factors: US Gas production by type (source: EIA)

All that projected development is based on sufficient available volumes of the commodity and one more key-factor, the constant price which is translated into an elastic supply.

The extensive shale gas production has drove the domestic prices of the commodity into the low levels of approximately 3.65 $ /mbtu

Thus, with such low prices there is a growing discussion about the possibility for U.S to be LNG exporter the following years in order to take advantage of arbitrage opportunities that exists between domestic prices and those of Europe and Asia which are relevant high. In the following chapters the author will attempt to deepen the analysis of shale gas impacts on natural gas prices.



[Figure 12] Natural Gas Consumption Factors: Range of shale gas forecasts (source: British Gas)

According to [Figure 12] the projections of for shale gas production levels vary significantly. For instance, the forecast for shale exploration in 2020 has a range from approximately 30 to 60 bcf (billion cubic feet).

In addition, it is worth to be mention that another elements which influence the natural gas demand and supply is the policy direction to reducing emissions, which will be analyzed in the next paragraphs, the use of LNG as bunker fuel, the diversification of energy resources as well as the stored natural gas volumes which in short-term could balancing prices fluctuations.

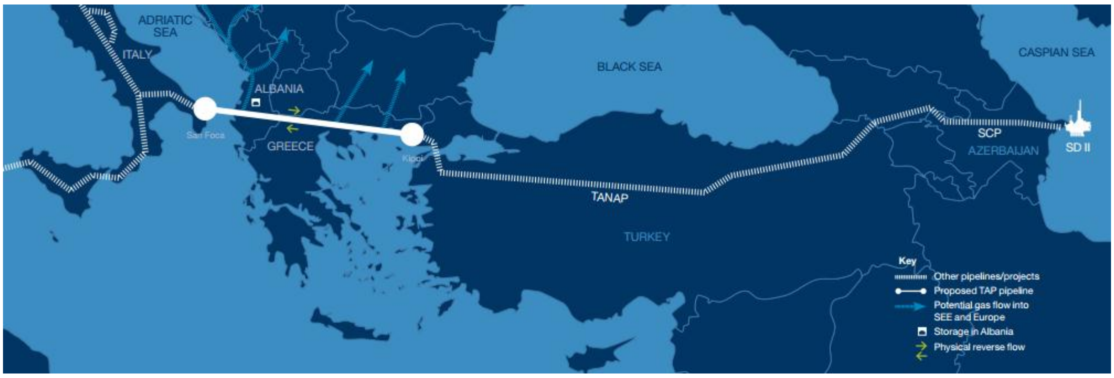
2.3 European Union Policy

A significant impact on natural gas consumption coming from EU policy which mainly is based on two (2) pillars: energy diversification and security as well as reduction of CO2 emissions and efficiency.

The gas crisis of 2009 led the half of the continent without sufficient gas supplies and exposed Europe's dependency on energy imports which at present represent the 60% of its gas. With imports of natural gas rising to 70-80% by 2030 energy dependency will be a major risk and led to possible significant economic damage. Therefore EU needs to diversify suppliers and supply routes to avoid being dependent to a single exporter. Above all, Europe needs to develop an internal well-functioning energy transit network.

The European Commission introduced the European Energy Program for Recovery (EEPR), an allocation of 4 billion euros to 59 infrastructure energy projects to reduce greenhouse emissions, promoted renewables and provide energy security to the community.

Energy diversification depends on major new gas infrastructure projects to link Europe with gas rich continents through strategic initiatives such as the TAP pipeline [Figure 13].



[Figure 13] European Union Policy: The Trans Adriatic Pipeline (source: TAP)

The Trans Adriatic Pipeline (TAP) is one of the newest gas projects with a vital importance for EU energy supply. With 867 km and running from the western border of Turkey throw Greece and Albania, Tap will connect Caspian gas to European Markets.

Currently the role of LNG is rising, Europe is seeing the merging benefits of that ‘green’ and reliable energy resource. Thus, EU invests to several LNG projects such as a new 200km pipeline from Hungary to Croatia enabling better access to possible LNG terminals on the Adriatic coast as well as connecting to the central European gas corridors and new LNG terminal in Poland.

In the effort to prevent the most severe impacts of climate change, European Union set a new policy focused on cutting its emissions. The climate change and energy sustainability is one of the main pillars of Europe 2020 targets. The main goals of that measure are based on greenhouse gas emission reduction of 20% lower than 1990, increase in energy efficiency and renewables.

Regarding the air emissions, Europe has a clear focus on renewable source of energy and natural gas. Even if it’s a fossil fuel, the burning of natural gas produces considerable lower quantities of carbon dioxide than coal or oil.

2.4 LNG prices

According to the research of Brown and Yucel (2007) for Federal Reserve Bank of Dallas, for many years natural gas prices were closely aligned with those of crude oil. Several rules of thumb have been used in order to determine natural gas prices. On simple rule, which seems to have been developed from number of observations, is that of the 10/1 analogy which set the natural gas price to one-tenth of the crude oil price. Another common simple rule is about the energy content of a barrel of crude oil. As the barrel of WTI contains 5.825mbtu of gas some researchers found 6 to 1 analogy. Eventually none of those simple rules seems to perform accurately as the actual gas prices appear to be somewhere between that two (2) analogies. In addition they mention few additional factors driving natural gas prices such as seasonality weather and storage volumes.

Another study from Peter Hartley and Kenneth Medlock presents the relatively long-term relationship between WTI and Henry Hub prices following by seasonal fluctuations from factors such as the weather and inventory trends.

Currently the globalization of the LNG market is far from a likely outcome at least for the close future. Currently the market doesn't experience a global spot price for the commodity. The trading is dominated by forward contracts, basically spanning to twenty (20) years. (W. R. True, 2008). The pricing for LNG has many differences per region as Asia-Pacific and Atlantic-Mediterranean, which represent the main markets, show big variation of prices. In author's point of view, the global oil and oil products market is a difficult example to follow due to the surged liquefaction, transportation and re-gasification costs found in natural gas by being in liquid form.

"Liquefied natural gas related to North American market is priced according to the clearing natural gas price set generally at Henry Hub, in South Louisiana, and that tends to dominate movements within the extensive North American pipeline system. That price reflects demand especially in the Lower 48 market; it does not have reference to any European price because most of the gas that moves in North America is still produced in North America." (W. R. True, 2008)

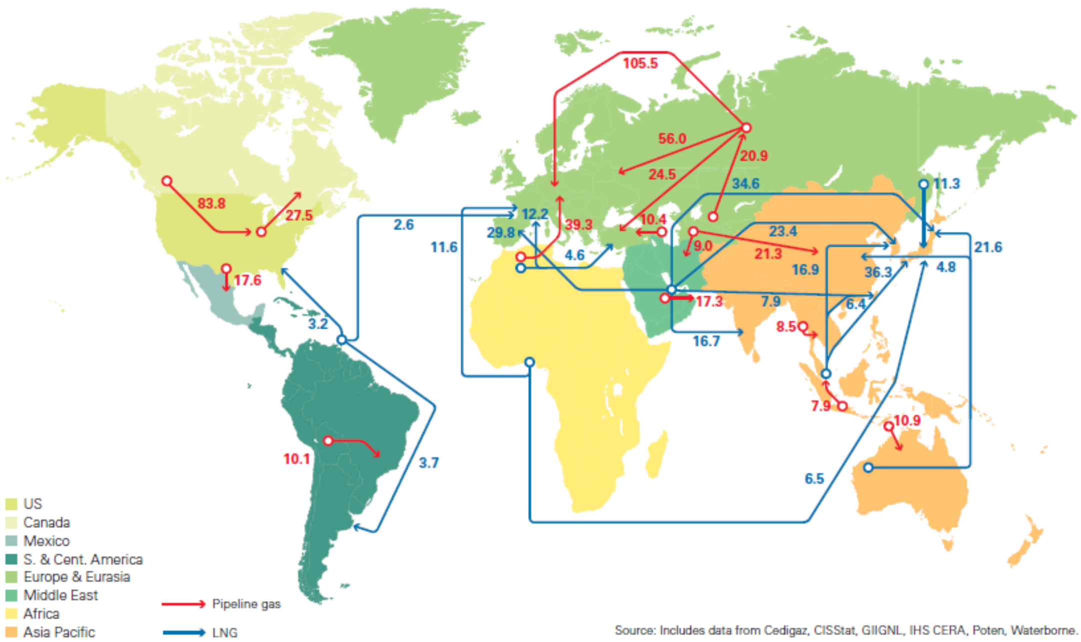
"Something similar is true for Europe. There, much of the gas, especially to, from, and for the UK uses the nominal National Balancing Point (NBP) price as reference. For the rest of Western Europe, however, there are several other trading markets. Natural gas coming in as LNG competes with the much larger quantities of gas that enter European markets via pipeline from North Sea fields, Russia via Eastern Europe, and North Africa via Italy and Spain. Pricing for both LNG and pipelined natural gas tends to follow oil and oil products when part of long-term contracts." (W. R. True, 2008)

“Asia is another case altogether. In the oldest and largest LNG market, Asian natural gas prices are generally referenced to crude oil prices. This is exemplified by the bulk of Asian sales to Japan being indexed to the Japan Customs Cleared price, or “JCC” (also known as the “Japan Crude Cocktail”). It is not the only crude-price reference market; Indonesian sales are also linked to a crude oil index. Such pricing structures differentiate the Asian market from the rest of the world.” (W. R. True, 2008)

Another key element related to natural gas prices which is likely to emerge the upcoming years is the use of LNG as bunker fuel have been around for few years but confined in the Baltic Sea and Norway in particular. Increasing regulations about the reduction of co2 emissions as well as the high oil prices have made LNG a cost effective solution for bunkering. Clearly, if this project will be widely available to deep-sea vessels will have an important impact on commodity prices as will boost the demand.

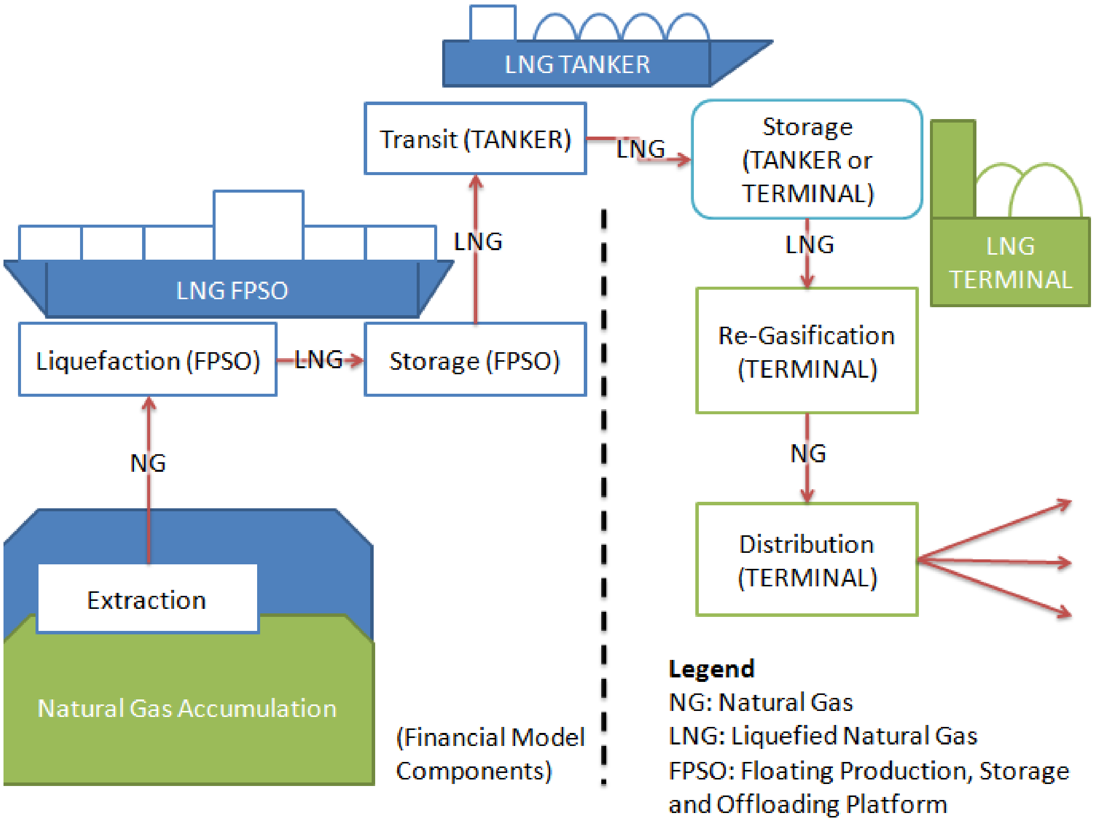
2.5 LNG Transit & Vessels

At present, Natural gas liquefaction is the only proven method which enables the commodity to be profitable transported via sea over long distances. On the other hand, transportation via pipelines is a competing method and the major mode for the trade of the commodity. Big discussion arises when decision makers considering LNG or pipeline as a route of transit together with the related capital expenditures. The [Figure 14] indicates the different trade movements of the commodity via pipelines and vessels.



[Figure 14] LNG Transit & Vessels: Major natural gas trade movements in Billion cubic meters both via pipeline and Sea in 2012 (source: BP Statistical Review of World Energy June 2013)

Natural Gas at standard temperature and pressure (STP) conditions has much lower density than oil. The above argument supports the observation of the fast growing pipeline network which provides natural gas to the terminals with high capital expenditure but relatively low operating and maintenance costs.

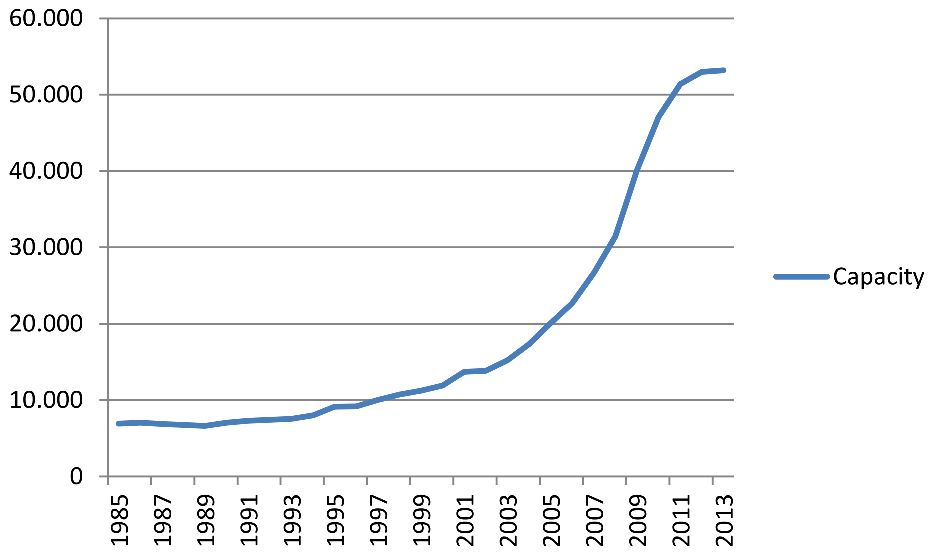


[Figure 15] LNG Transit & Vessels: The Integrated LNG System

The method of transit natural gas in LNG state is composed of a series of different steps. [Figure 15]: the natural gas extraction, liquefaction, storage, transit and optional storage and finally the regasification and distribution. In this case the above figure presents the extraction and liquefaction phases, which are made from an off-shore floating production platform (FPSO) while the LNG progressively transferred to LNG vessel. The LNG carrier transports the commodity to the designed terminal where either transferred to an storage tank or re-gasified and distributed via pipelines. “On arrival, at the customer’s terminal, the LNG is unloaded and stored until required. Before its use, it is re-gasified: in some instances, part of the vast quantities of cold gas released during this process finds commercial use, for example as cold for frozen food and air separation.” (Majid, 1992)

The first sea transit of LNG had been made in 1959 from United states to United Kingdom by the M/T Methane Pioneer (27.400m3) (lng trade and transport 2012) Between 2007 and 2010 the size of LNG vessels has been multiplied, for example the newly launched Q-Max LNG tanker with sophisticated equipment and incredible capacity of 226000m3. This type is specially designed to operate in projects in Qatar.

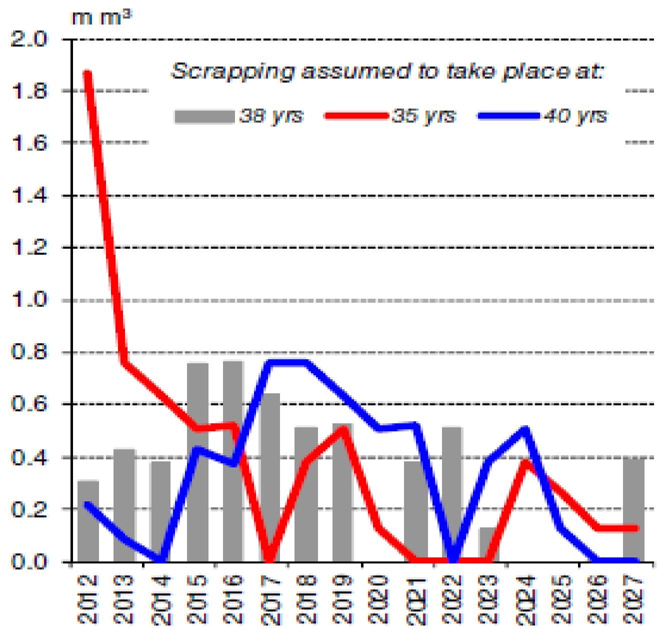
According to Clarksons the LNG tanker fleet has proven an exponential increase in the last decade [figure 16] where the global available capacity more than tripled, exceeding the 50 bln m3. The significant technological improvements in LNG storage, materials and engineering, had driven the volumes up.



[Figure 16] LNG Transit & Vessels: Global LNG Fleet Development (Clarksons)

The LNG vessels have an incredible long lifespan. For instance still today, the 71,500 cu. m. M/T *SCF Arctic* is still sailing after 44 years of operations while more than 5 similar LNG carriers are over 40 years. Based on the same recourse the average age of the global LNG fleet in 2012 is about the 11 years.

Scrapping in not the only way for the old vessels as many of them they could be used as Floating Storage Off-shore (FSO) platforms. Nevertheless the significant growth of the LNG fleet in the short-term maybe drives to higher levels of scrapping. Today the fleet contains many complex, highly sophisticated vessels with efficient engines and relatively low fuel consumption. That situation is very likely to make the older vessels less attractive to the shipping market leading them to scrap. The [figure 17] illustrates the estimations of the scrapping trends if the scrapping rate will remain at 38 years as it is today. By the 2014 according to this scenario only the 2.5% of the current fleet will be scrapped. Additionally in the graph there are 2 different scenarios of 35 and 40 years.



[Figure 17] LNG Transit & Vessels: Potential Scrapping trends of LNG vessels.

Regarding the major sea routes for LNG transit, there are two (2) main geographic territories where the trade is taking place. The first covers the area of Asia-pacific and is by far the biggest market of LNG with Japan holding almost the half of the Asian imports and placed on the top of natural gas importers worldwide. In 2012, based on BP’s LNG trade movement analysis, Japan logged a record imported volumes of 118.8 billion cu m mainly because the nuclear power plants shutdown of the tsunami of 2011.

Lately, China with an extensive project of terminals under construction is emerging as a considerable LNG importer with almost 8% stake on the Asia- Pacific LNG imports. (BP)

The second area of interest is that of Atlantic-Mediterranean, dominated from Europe's and North American imports. In this point as it is mentioned before, U.S coming up as net LNG exporter thanks to the extensive shale gas developments and forecasts for further expansion of the sector. By the time, there is no significant trade flow between the two main territories of Asia and Atlantic except the export volumes from Norway to Asia.

Finally the Middle East, as is placed in between and being rich of natural gas reserves, exported last year approximately 135 billion cu m LNG via sea mainly to Asian countries.

The sea transport of LNG, similarly to other cargo transits by the sea, is determined form supply and demand. The supply of tonnage and the demand for sea transport, which is a derived demand, are the two pillars composed from a series of sub-elements. Thus, the interaction of supply and demand set the market for that particular se trade.

2.6 LNG Infrastructure

The liquid natural gas using trains, trucks and LNG ships can be transported to the special re-gasification terminals providing gas to the relevant markets. During the last 30 years the increasing requirements for natural gas of countries such as Japan and Korea drove the import technology to reach the establishment of high cost expenditure pipeline infrastructure.

[Figure 18] LNG Infrastructure: Umm Slal, a Q-Max LNG ship, delivers cargo at Singapore LNG Corp's new terminal.

The increasing demand and price of natural gas were the 2 main key-factors to the development of the Asian LNG industry. The rising LNG traffic rates and expanding of LNG fleet are proof of the boom liquefied gas has undertaken in the last decades. The fact of natural gas liquefaction and transportation in huge volumes across the oceans via LNG vessels has expanded the market. At the same time lower storage and operating costs from technological developments and economies of scale, have opened up the domestic market into global domain. The currently placed infrastructure for LNG has increased the viability of projects under consideration which used to have a marginal benefit for the investors. Based to Majid (1992), The LNG projects used to have about 10 year development duration including the whole related stages from design up to commissioning. Today, few years later, the improvement for materials, construction technics and information available have brought down the development of LNG projects to an average of five years (Shell International Gas Ltd 2010)

2.7 LNG FPSO

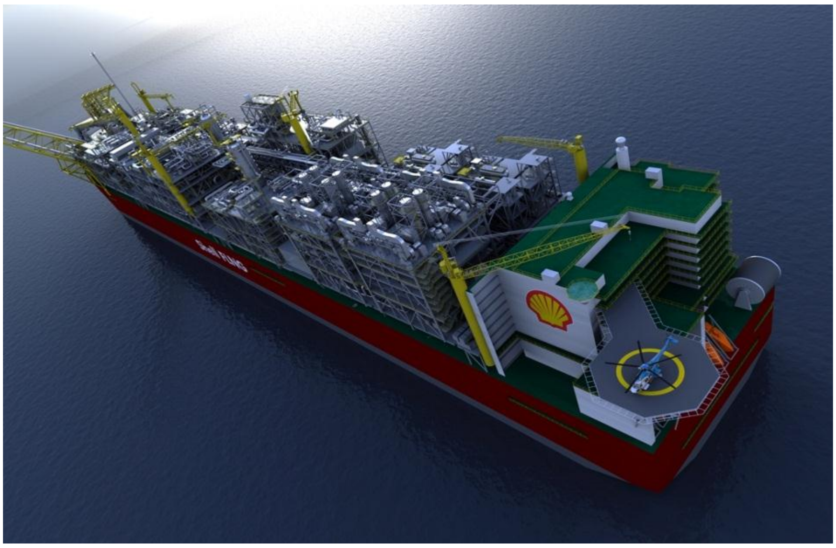
Over the last 2 decades, the Floating production storage and offloading platforms (FPSO) have become popular for extracting oil and gas from deep-water stranded fields. Such facilities decrease the production costs as they do not need pipeline networks and shore infrastructure.

«Key technical challenges, such as LNG storage systems, that accommodate sloshing due to vessel movement and the transfer of LNG from the storage system to a carrier vessel, have been solved. As a result, for the first time, offshore LNG production could now be practically at a lower cost than onshore LNG production, especially as there are many remote offshore gas fields that could provide the gas for liquefaction. » (Finn, 2008)

The FPSO concept is not new one. It's begun since 1978 with the 'Kangan FPSO'. The last years, an important effort by a number of market leaders in the design and development of FPSO for LNG has been made in order to provide the market with the valuable commodity but also to make the production more efficient.

Although there are a number of FPSO successfully extracting oil and seem to be a great solution in deep-water gas recovery, due to the special specifications of different fields only lately and under the effort of market leaders, floating liquefied natural gas (FLNG) facilities are in development.

The-state-of-the-art in FLNG market is the well-known Royal Dutch Shell's project called *Prelude* [Figure 19] which is planned to start operations north of Australian coasts.



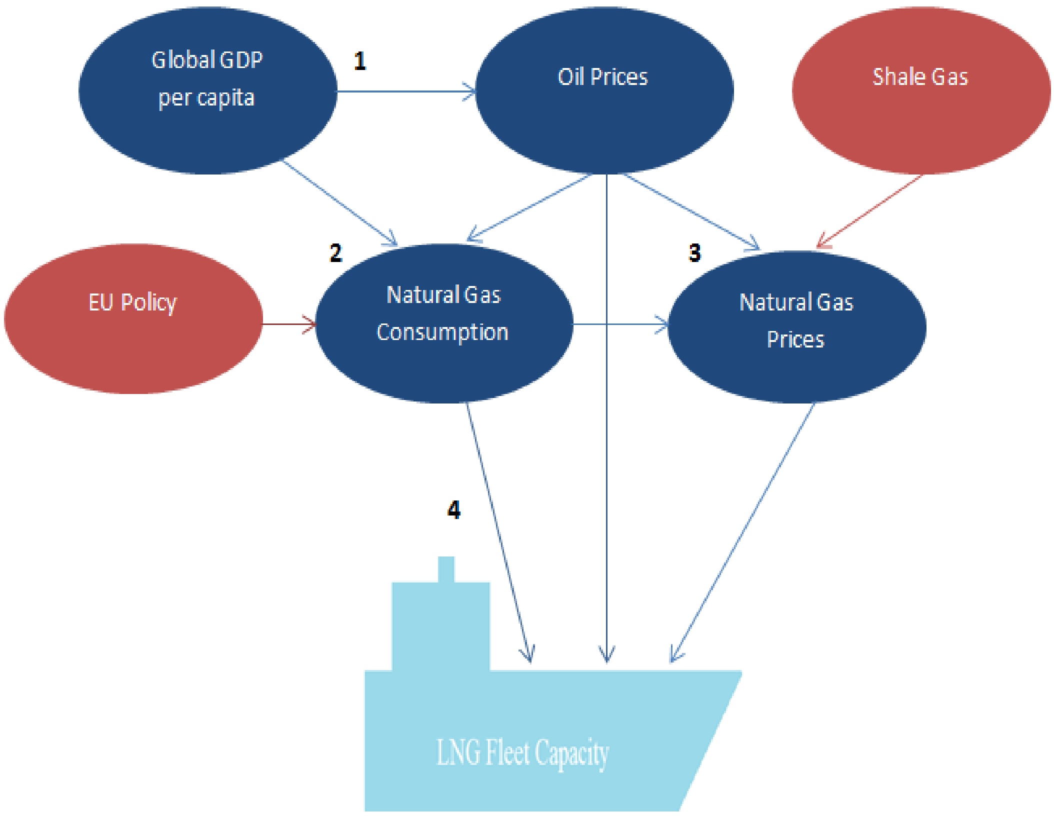
[Figure 19] LNG FPSO: Shell's FLNG *Prelude* (source: Shell)

«When completed, the Prelude FLNG facility will be 488 meters long and 74 meters wide, making it the largest offshore floating facility ever built. When fully equipped and with its cargo tanks full, it will weigh more than 600,000 tones. There will be over 3,000 kilometers of electrical and instrumentation cables on the FLNG facility, the distance from Barcelona to Moscow. » (Bichsel 2012)

3. Methods and Methodologies

3.1 Research Model

In order to investigate the factors which determine the capacity of global LNG fleet, a research model has been created [Figure 20] based on the previous empirical overview of the LNG market.



[Figure 20] Research Model: The determinants of LNG fleet capacity

The {graph} illustrates how the proposed model works. There are seven major variables:

- Global GDP
- Oil Prices
- Shale Gas
- EU Policy
- Natural Gas Consumption
- Natural Gas Prices
- LNG Fleet Capacity

In order to execute the calculations only the 5 of them will be used, all except Shale Gas and EU policy. Those two (2) factors clearly the have an impact on natural gas market but regarding the EU policy is not applicable for the particular thesis to quantify this variable. On the other hand the Shale gas dynamic is still not clear as there are serious considerations of in which extent that new exploration method will expand. Thus the model will be based on the other five well based and specifically defined variables.

Those variables are related via several paths and relationships. Actually the idea is based on four (4) basic stages. To be more precise:

1. The correlation between global GDP and Oil prices.

2. The determination of natural gas consumption.

3. The determination of natural gas prices.

4. The determination of total capacity of LNG vessels

3.2 Research Hypotheses and Scenarios.

After the formulation of the research model, few hypothesis and scenarios related to the different relationships among the variables have been made.

1. The first hypothesis presents the correlation between world's GDP and Oil prices.

2. Secondly, the global consumption of natural gas can be predicted from the global GDP and Oil Prices.

3. The third research hypothesis is referring to the fact that the oil prices, natural gas consumption can determine the natural gas prices.

4. Finally, the total capacity of LNG tankers is related to natural gas consumption and prices.

Despite the different relations among the variables which can be quantified, the impacts from variables such as the EU policy is not clearly identified. Regardless that uncertainty, based on the previous analysis of the empirical framework the European Union via it is energy policy is likely to boost natural gas consumption even higher that the current predictions. Thus two (2) scenarios have been conducted in effort to forecast the LNG fleet capacity for the next five (5) years. A low scenario which illustrates a 1.5% annual growth of the commodity's consumption, following by a high scenario of 5% annual growth which reflects the EU impact.

In addition, the difficulties to identify the effect of shale gas development on natural gas prices were the springboard to introduce two (2) additional scenarios, one of low natural gas prices between 3 and 4 related to the extensive utilization of shale gas technology and another of higher prices of 6 to 7 during the next 5 years which illustrates the limited shale gas extraction.

3.4 The Methodology

The selection of the proper research method is very important for a successful dissertation. The main choice for every researcher is whether qualitative or quantitative approach should be used as well as the nature of the data (primary or secondary).

The Quantitative research as principle uses numbers and statistical techniques. It mainly is based on numerical aspects of specific phenomena and seeks measurements and analyses that are replicable by other investigators easily. (King, Keohane & Verba 1994 3-4)

Researchers using quantitative methods seek explanations and forecastings that could generalize to other samples. Thus, careful sampling and experimental procurer are aspects which aimed to produce generalized results. (Glesne & Peshkin 1992 6)

On the other hand, in the qualitative research the investigator describes selected aspects of people or phenomena without comparing them in terms of calculated amounts.

The Qualitative method, a multimethod, is focused on things in their natural settings, attempting to make valuable findings or interpret phenomena while use collection of huge variety of empirical data. (Denzin & Lincoln 1994 1)

Besides the different research approaches, based on Ranjit Kumar, there are two (2) types of data that researchers use when they are carrying out research studies. Most of the situations,there is a need to collect the required data, however, sometimes the information required is already available and need only to be extracted. Based upon these different approaches of data information gathering, data can be categorized as:

Primary data: Is one which is collected by the investigator himself for the purpose of a specific inquiry of study. Such data is original and is generated by surveys conducted by individuals or research institutions.(Dipak Kumar Bhattacharya 2006)

Secondary data: When an investigator uses the data which has already been collected from others, such data is known as secondary data. This data is primary data from the agency that collects it and becomes secondary data for someone else who uses this information for his own purposes. The secondary data can be obtained from journals, reports, publications of professional and research organizations etc. (Bhattacharya 2006)

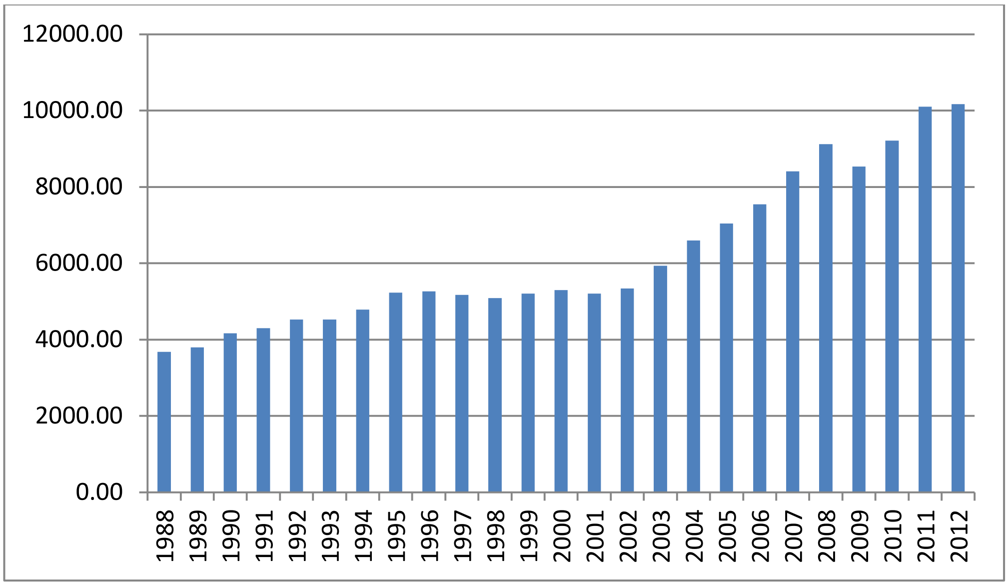
Both types of data have their own pros and cons. In many cases the nature of the research determines the choice of what kind of data must be used. This study in particular, which requires arithmetical data of more than two (2) decades will be handled with secondary data.

3.5 Data Analysis

3.5.1 Global GDP per Capita

The GDP per capita (measured in current $) has been selected over GDP as the first one taking into account the growth of population. The changes in population have significant impacts on energy consumption both for industry and home use.

The following [Figure 21] is presenting the development of global GDP per capita from 1988 to 2012.



[Figure 21] Global GDP per capital: Development 1988-2012 (in current $)

It can be noticed that there is an upward increase during the period except the year of 2009 where the global economy faced a downturn from the financial crisis of 2008.

Mean	6169.546
Standard Error	401.5495
Standard Deviation	2007.748
Sample Variance	4031050
Minimum	3677.761
Maximum	10170.68
Count	25

[Table 1] Global GDP per capita: Descriptive Statistics

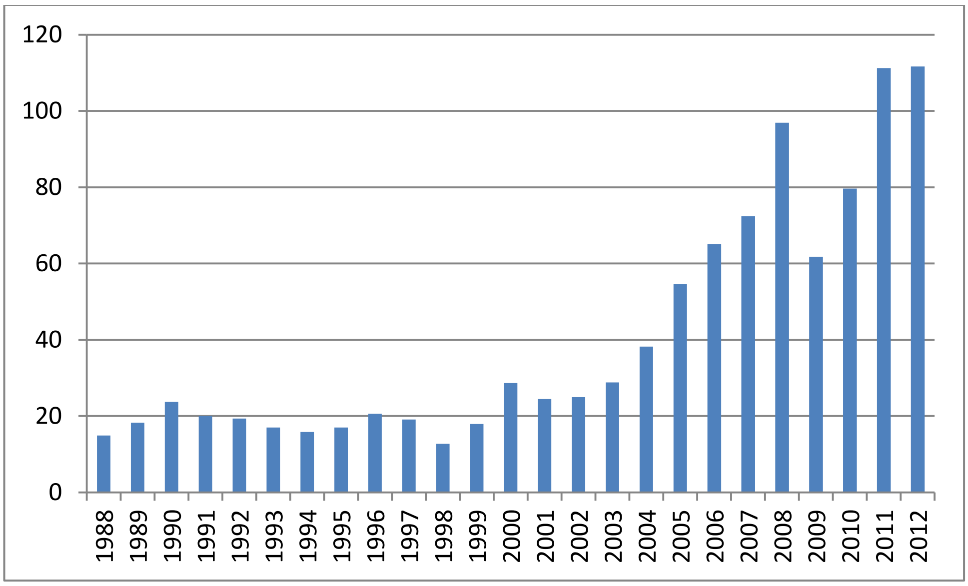
Looking on the [Table 1] above, the most important statistical data for the particular variable have been presented. The average GDP per capita logged on 6169.55 $ while the minimum amount is at 3677.76 $ and the maximum 10170.67 $ respectively. Overall the GDP per capital almost tripled during those 25 years

3.5.2 Oil Price

The price of Brent crude oil (measured in $ / barrel) has been selected as it is considered to be a very good indicator for the commodity's prices. Despite most Brent is destined for market in Europe, it's widely used as a price benchmark.

"Brent represents the Northwest Europe sweet oil market, but since it is used as the benchmark for all West African and Mediterranean crude, and now for some Southeast Asia crudes, it's directly linked to a larger market." (Bloomberg Report 2010)

The [Figure 22] illustrates the Brent price development during the 25 year investigating period. Until the 1998, which is the lowest point of the distribution, price follows a stabilized pattern. From 1999 there is a sharp increase trend with small stabilized period in 2001-2002. In light of the financial crisis, in 2009 oil price fall significantly almost to the 2/3 level of previous year.



[Figure 22] Oil Price: Development 1988-2012 (in $ per barrel)

The oil price has been recorded many fluctuations among that 25 years, as the minimum price was about 13.75 $/barrel while the maximum over 111 $/barrel. The average price is approximately 40 $/barrel [Table 2].

Mean	40.6052
Standard Error	6.321664
Standard Deviation	31.60832
Sample Variance	999.086
Minimum	12.76
Maximum	111.63
Count	25

[Table 2] Oil Price: Descriptive Statistics

3.5.3 Natural Gas Price

Natural gas prices were initially fixed from the federal government which had the jurisdiction over the commodity. The pricing methodology was something like the method of rate of return for pipeline tariffs, a faction of estimated costs of exploration and production of natural gas.

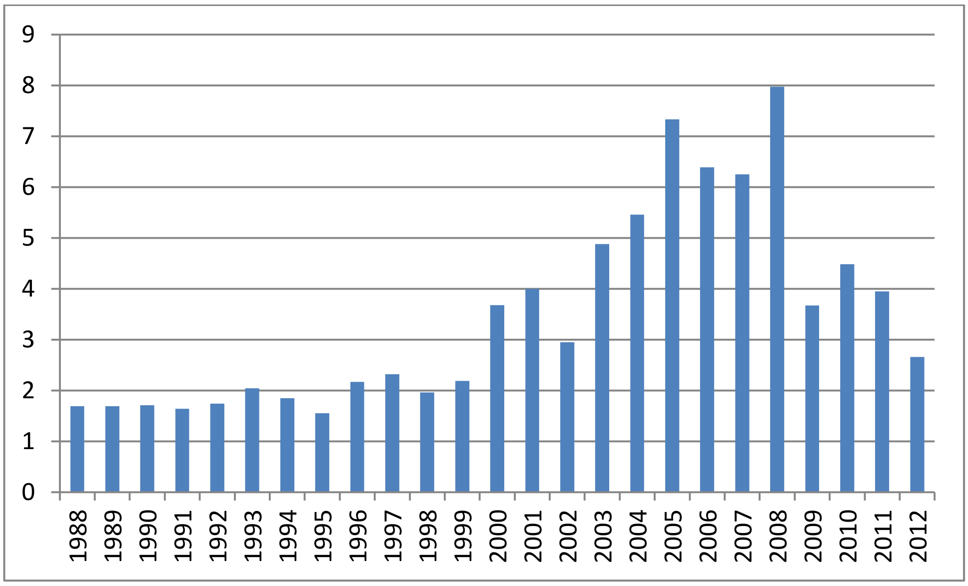
After natural gas was deregulated, the price became a reflection of the whole real economy with classic supply and demand factors and the influence of the speculators. Regarding the economic aspect of energy content, natural gas price for a thousand cubic feet should be close to one-sixth the value of 42 gallon barrel of oil. As the crude oil prices increased significantly, the price of natural gas seldom matched to that ratio.

The basic place for pricing the commodity is the wellhead. The wellhead price, measured in Btu, is the net price received by the producers without the additional costs to get further on the chain. Thus natural gas purchased at the wellhead is under the wellhead price. On the other hand, when the commodity is sold at the market center (hub) is done so on hub price. Hubs can be ideal place for gas pricing as they carry extremely huge volumes of the commodity. The most famous is the Henry Hub, Louisiana. The New York Mercantile Exchange (NYMEX) use as point of delivery for the natural gas future contracts the Henry Hub as it is very well located and easy accessible. (Doty, Turner, 2009 523-525)

Henry Hub is relatively new point of pricing and lacking data for the required period of time. Thus wellhead price (measured in $ / mcf) will be used for that research.

According to EIA the two (2) natural gas prices are liner correlated, so the use of wellhead price is a good indicator of market price.

Based on [Figure 23], there is a smooth fluctuation of the price until the minimum point of 1995. The following years, natural gas prices sharply increased and almost quadrupled in 2008 while in 2009 prices fell down to the levels of 2000.



[Figure 23] Natural Gas Price: Development 1988-2012 (in $ per MCF)

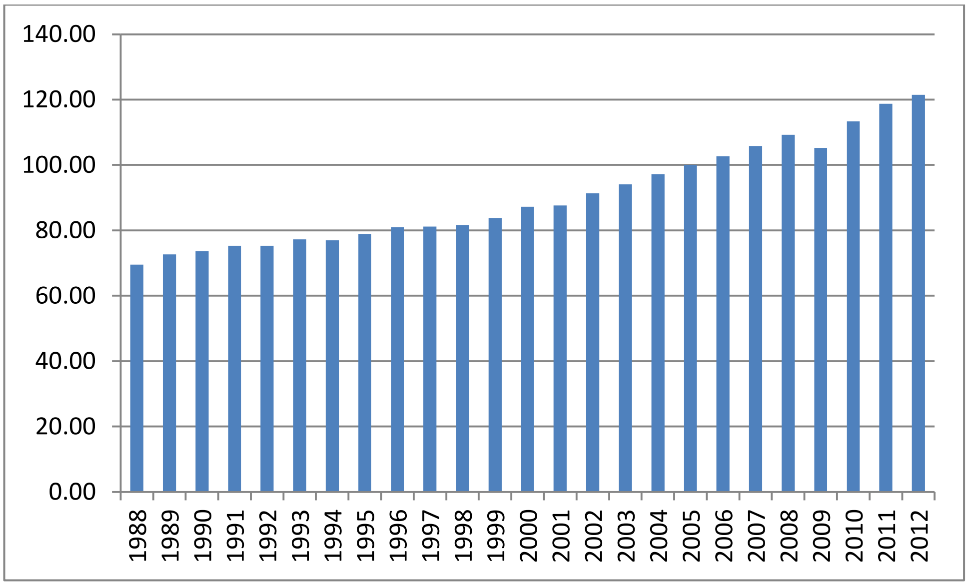
The natural gas price is dominated from fluctuations from 1988 to 2012 with minimum point at 1.55 USD/ mcf and maximum almost 8 USD/ mcf. Additionally, the average price is logged at 3.45 USD/ mcf [Table 3].

Mean	3.4488
Standard Error	0.389329
Standard Deviation	1.946645
Sample Variance	3.789428
Minimum	1.55
Maximum	7.97
Count	25

[Table 3] Natural Gas Price: Descriptive Statistics

3.5.4 Global Natural Gas Consumption

Based on the following [Figure 24], the natural gas consumption (measured in trillion cf) has shown a clear upward trend during the 25year period. Only in 2009 record a decline but from 2010 continued with upturn.



[Figure 24] Global Natural Gas Consumption: Development 1988-2012 (in TCF)

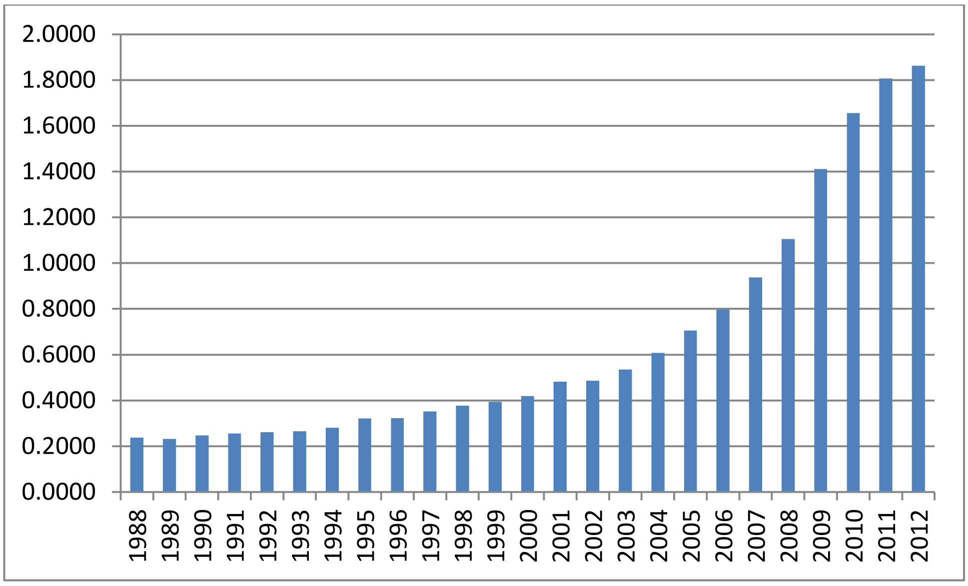
The average global consumption of natural gas is about 90.5 tcf [Table 4]. The minimum is located on 1988 with 96.6 tcf while the maximum coming in 2012 with 121.4 tcf.

Mean	90.45261
Standard Error	3.080065
Standard Deviation	15.40033
Sample Variance	237.17
Minimum	69.57337
Maximum	121.4401
Count	25

[Table 4] Global Natural Gas Consumption: Descriptive Statistics

3.5.5 Global LNG fleet capacity

The LNG fleet capacity (measured in Billion cf) has experienced a dramatic increase from 1988 to 2012. The LNG carriers' tonnage rose almost 9 times during that period [Figure 25].



[Figure 25] Global LNG fleet capacity: Development 1988-2012 (in BCF)

The total capacity of LNG fleet is a continuously increased variable. The average tonnage is 0.65 bcf. The minimum point on the beginning of the examined period is about 0.23 bcf, while the maximum in 2012 was around 1.86 bcf [Table 5].

Mean	0.65422
Standard Error	0.103083
Standard Deviation	0.515416
Sample Variance	0.265654
Minimum	0.232547
Maximum	1.862783
Count	25

[Table 5] Global LNG fleet capacity: Descriptive Statistics

4. Results and Findings

4.1 Regression Analysis

As it has been mention, in the previous chapter, the proposed model is a four (4) stages model using 5 variables. Those variables are related to each other via many different paths. In the cases when two (2) or more relations end up to the some dependent value, then those paths can be combined in order to create multiple relations with many dependent and one independent variable. Thus, four (4) relations have been analyzed and represent model's research hypothesis as introduced in chapter 3.

Hence, firstly the Global GDP per capita can determine the oil Price. The second relation under examination is that the global natural gas consumption can be explained from GDP per capita and oil Price. Afterwards, as third stage is the relation of natural gas price with the oil price and natural gas consumption. Finally the main analysis which is conducted in order to answer the main research question is in which extend the LNG fleet capacity can be explained from oil price, natural gas consumption and natural gas price.

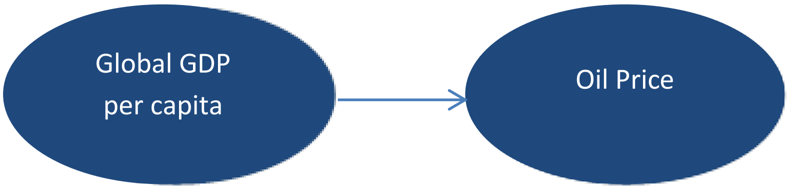
The examination of the strength of those relations has been made using multiple regression analysis provided from *Data Analysis* of *Microsoft Excel 2010*. To be more precise, four linear regressions have been performed: one (1) single linear regression and three (3) multiple linear regressions.

Regarding the data, the cubic feet (cf) and United States dollar ($) have been chosen.

- Global GDP per capita measured in current $.
- Oil Price measured in current $ per barrel.
- Natural Gas Price measured in current $ per thousand cubic feet (mcf)
- Global Natural Gas Consumption measured in trillion cubic feet (tcf).
- Global LNG vessels capacity measured in billion cubic feet (bcf).

4.1.1 Single Linear Regression

This relation is between two (2) variables, one dependent (Oil Price) and one independent (Global GDP per capita).



In order to ascertain the strength or not of that particular relation, single linear regression has been performed.

Regression Statistics	
Multiple R	0.962324
R Square	0.926068
Adjusted R Square	0.922853
Standard Error	8.779304
Observations	25

[Table 6] Single linear Regression: Regression Statistics

The R indicator is calculated to 0.962 which means that there is a strong positive linear relation between Oil Price and global GDP per capita. The R^2 (coefficient of determination) is a statistic which tell us what percent of depend variables variation is explained by the variation of the independent variables. Thus in this case, it shows that the 0.926 of the oil price can be explained from the global GDP per capita.

In order to examine the importance of the results the researcher must check the ANOVA which stands for Analysis of Variance. As it is illustrated at the [Table 7] there is a great influence of Global GDP per capita on the Oil price which is statistical significant. [$F(1,23)=288.09$, $p<0.001$]

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	22205.31	22205.31	288.0956743	1.672E-14
Residual	23	1772.752	77.07617		
Total	24	23978.06			

[Table 7] Single Linear Regression: Anova Table

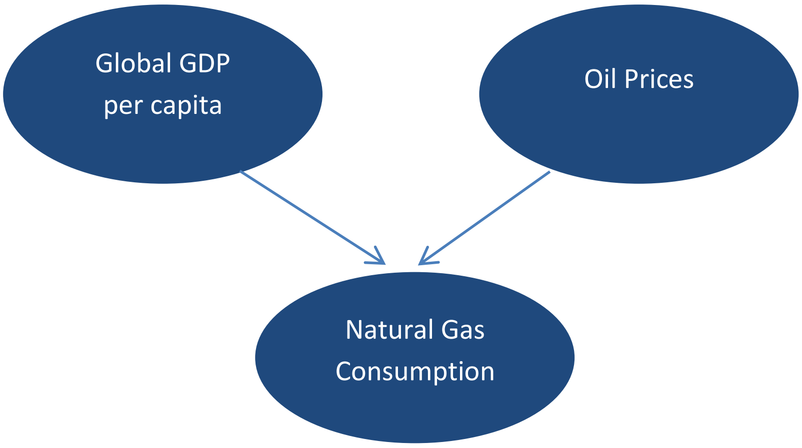
Based on the Coefficients Table [Table 8] there is a statistical significant influence of Global GDP per capita on the Oil price [$t(23)=16.97$, $p<0.001$].

Thus for a 1 USD increase of the global GDP per capita, the oil price is increasing 0.015 USD per barrel.

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-52.86365	5.779947	-9.146044	4.00642E-09
GDP	0.01515	0.000893	16.97338	1.67205E-14

[Table 8] Single Linear Regression: Coefficients Table

4.1.2 1st Multiple Linear Regression



Regression Statistics	
Multiple R	0.98078
R Square	0.96193
Adjusted R Square	0.958469
Standard Error	3.138464
Observations	25

[Table 9] 1st Multiple Linear Regression: Regression Statistics

In multiple linear regression analysis, as the R^2 tend to be increasing, the use of adjusted R^2 is preferable as it takes into account the sample size and the number of independent variables. In this case [Table 9], the adjusted r2 is 0.95 which means that the two (2) independent variables explain the 95% of the dependent variable's variations

Regarding the ANOVA [Table 10] there is a strong relationship between the 2 dependent variables and the natural gas consumption [F (1, 22) =277.93, $p<0.001$]

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	5475.381	2737.691	277.9394	2.4347E-16
Residual	22	216.699	9.849956		
Total	24	5692.081			

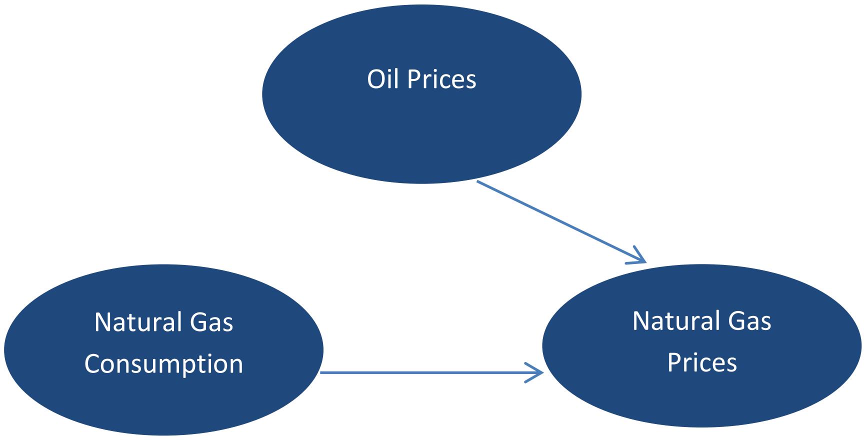
[Table 10] 1st Multiple Linear Regression: Anova Table

As it is seen from the table of coefficients [Table 11], indeed there is a statistical significant influence of GDP per capita on Global Natural Gas Consumption while the relation with the Oil Price is not significant. In this point it could be examined the role of external factors such as the environmental policy of European Union which boost the use of natural gas. All in all the weakness to identify the factors which determine the natural gas is not vital as do not influence directly the final model, it is a given variable.

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	41.88249	4.449361	9.413146	3.59E-09
Oil Price	-0.04103	0.074541	-0.55047	0.587542
GDP	0.008143	0.001174	6.938708	5.76E-07

[Table 11] 1st Multiple Linear Regression: Coefficients Table

4.1.3 2nd Multiple Linear Regression



In this case, the variances in Oil Price and Natural Gas Consumption explain the 42% of Natural Gas Price.

Regression Statistics	
Multiple R	0.688757067
R Square	0.474386297
Adjusted R Square	0.426603233
Standard Error	1.47405752
Observations	25

[Table 12] 2nd Multiple Linear Regression: Regression Statistics

According the Anova analysis [Table 13] there is a strong influence of Oil Price and Natural Gas Consumption on Natural Gas Price which is statistical significant ($F(1,22)=9.927917$, $p<0.001$)

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	43.14366	21.57183	9.927917	0.000845928
Residual	22	47.8026	2.172846		
Total	24	90.94626			

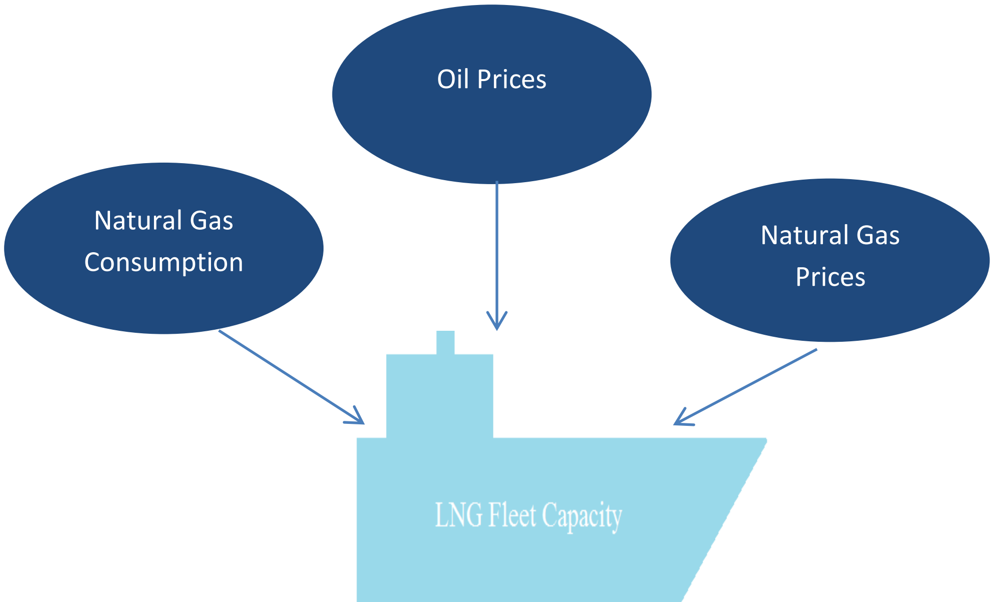
[Table 13] 2nd Multiple Linear Regression: Anova Table

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-6.63432724	4.061713	-1.63338	0.11662
Consumption	0.119168455	0.056079	2.125027	0.045057
Oil Price	-0.01713993	0.027323	-0.62731	0.536912

[Table 14] 2nd Multiple Linear Regression: Coefficients Table

As the [Table 14] shows, there is a statistical significant relation of Natural Gas Consumption and Oil Price with the Oil Price [$t(22)=2.125027$, $p<0.1$] and [$t(22)$ 0.62731, $p<0.1$]

4.1.4 3rd Multiple Linear Regression



This 3rd Multiple Linear Regression is the tool in effort to answer the main research question. The Regression statistics [Table 15] calculate the R at 0.98 which shows a strong linear relation between the LNG Fleet Capacity and the independent variables. The adjusted R^2 is 0.962 equals to 96% of the LNG Fleet variation can be explained from the model.

Regression Statistics	
Multiple R	0.983393
R Square	0.967062
Adjusted R Square	0.962356
Standard Error	0.100001
Observations	25

[Table 15] 3rd Multiple Linear Regression: Regression Statistics

In order to examine the significance of the results ANOVA [Table 15] has been conducted. Indeed the is a statistical significant influence of the tree (3) independent variable on the LNG fleet capacity [$F(1,21)=205.51$, $p<0,001$]

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	6.165688	2.055229	205.5194	1.01695E-15
Residual	21	0.210004	0.01		
Total	24	6.375691			

[Table 15] 3rd Multiple Linear Regression: Anova Table

Based on the following table [Table 16]

It appears a statistical important effect of the natural gas consumption on the total LNG fleet capacity [$t(21)=6.309$, $p<0.001$].

In addition the oil price has a statistical significant influence on the dependent variable [$t(21)=3.503$, $p<0,001$]

Also it appears with a statistical significance way that there is an effect of the natural gas price on the LNG vessels capacity [$t(21) = 6.071$, $p<0.001$]

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-1.69272	0.291779	-5.80137	9.29E-06
Gas Price	-0.08782	0.014464	-6.07172	5.03E-06
Oil Price	0.006552	0.00187	3.503311	0.002116
Gas Consumption	0.026354	0.004177	6.309845	2.95E-06

[Table 16] 3rd Multiple Linear Regression: Coefficients Table

From this regression analysis the following formula has be conducted.

[LNG fleet capacity]=-0.08782[Natural Gas Price] +0.006552*[Oil Price] +0.02635*[Natural Gas Consumption]-1.69272*

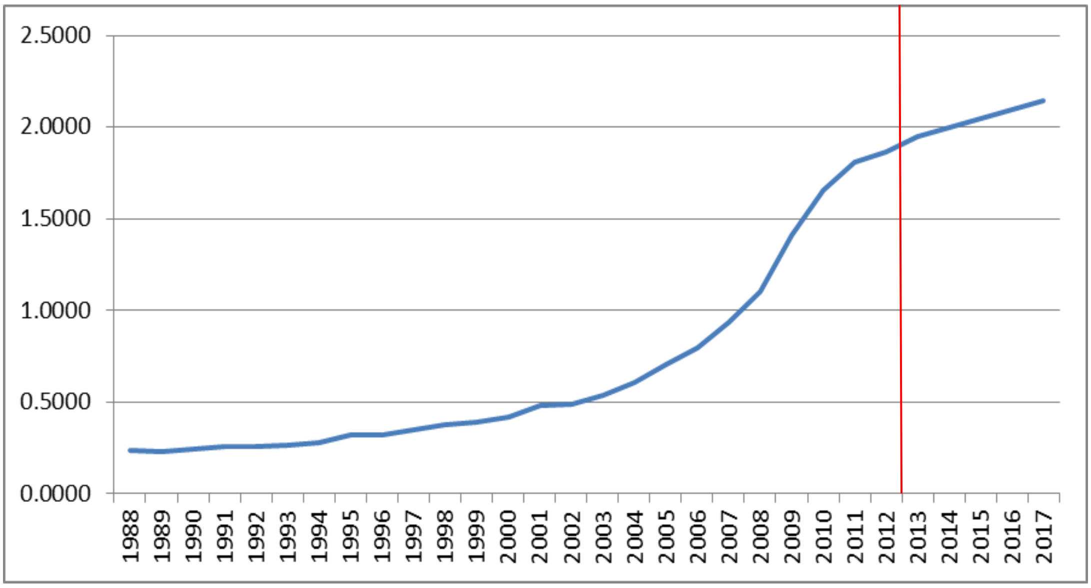
Based on this formula, the LNG fleet capacity can be predicted if the Natural gas price, Oil price and Natural Gas Consumption are known.

4.2 Scenario forecasting

4.2.1 Scenario forecasting: Natural Gas Consumption

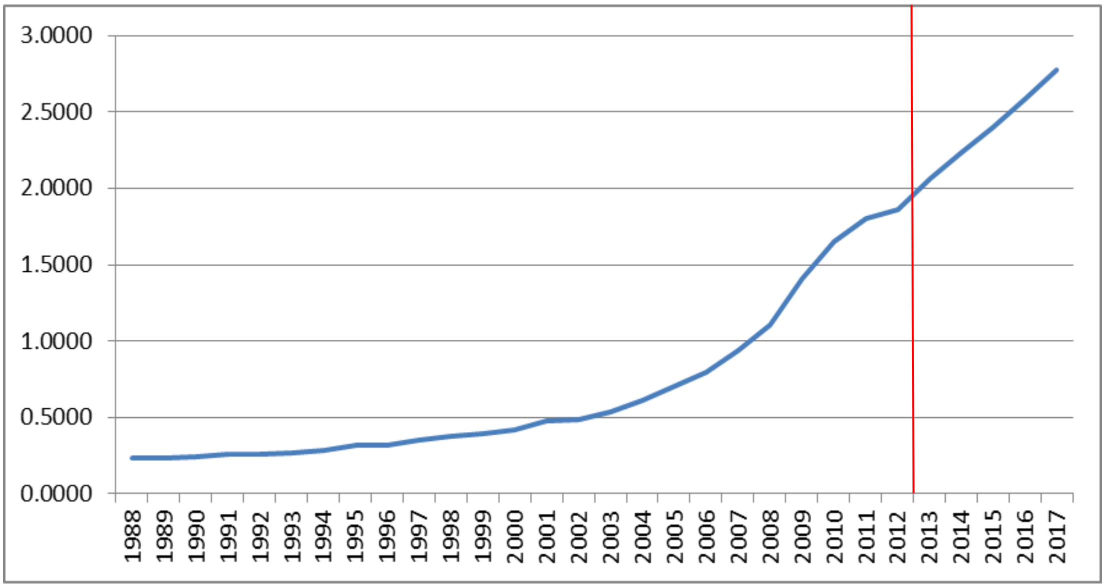
Taking into account all the current market reports, the natural gas consumption is expected to icrease the following years with an average growth rate between 1.5% and 3%. Despide the relatively low price of the commodtiy and the newly explored fields which will boost the supply, the role of the energy policy is very critical. The European Union consetration regarding the CO2 emissions and the diversification of the energy resourses is possible to increase even more the energy consumption. In effort to simulate those possible effects, the author examined two(2) senarions for the natural gas consumption trend in the next five(5) years. The first scenario estimates the LNG fleet capacity given an average yearly gas consumption growth of 1.5% whereas the second senario calculates the LNG vessels tonnage given an high natural gas consumption of 5%.

The [figure 26] illustrates the forecast of LNG fleet capacity given a 1.5% anual growth rate of natural gas consumption. The proposed model predicts an segnificand increase of the LNG fleet tonnage during the next five (5) years of about 13% reaching the 2.14 BCF by the 2017.



[Figure 26] LNG fleet capacity forecast given a 1.5% annual growth of natural gas consumption (source: author)

According the second scenario of high growth, the following [figure 27] shows the prediction for LNG fleet capacity given a 5% annual growth rate of natural gas consumption. Such a scenario is supported from the EU policy which is closely focused on the commodity for the reasons which mention in previous paragraphs. Thus, in this case there is a sharp increase of the fleet tonnage. During the period from 2013 to 2017 the fleet tonnage is estimated to expand about 45% and exceed the 2.77 BCF.

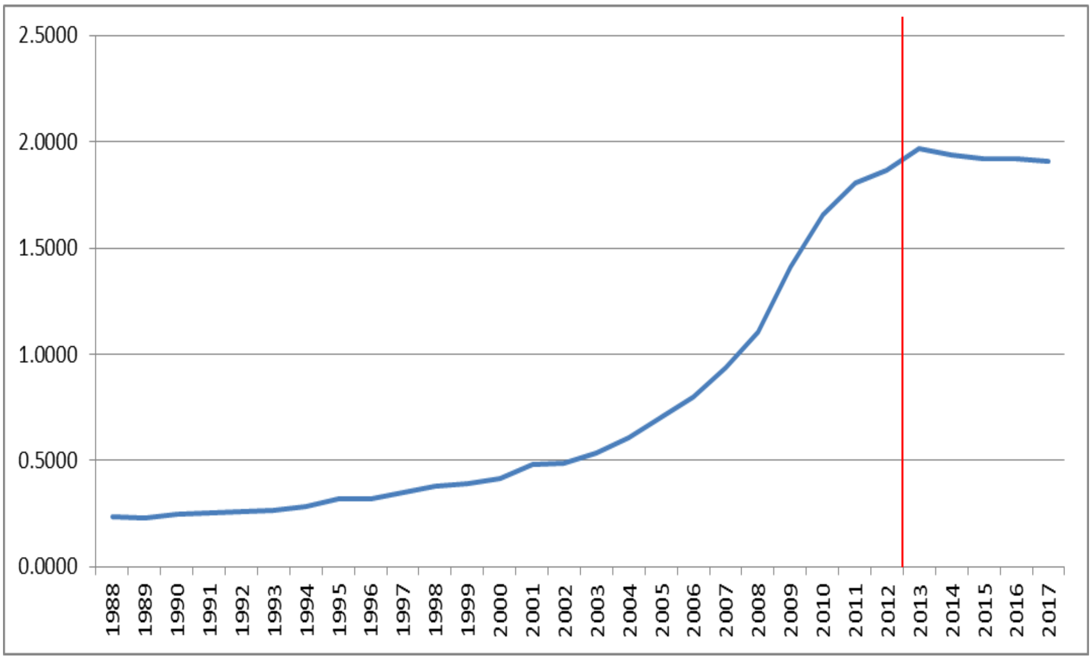


[Figure 27] LNG fleet capacity forecast given a 5% annual growth of natural gas consumption (source: author)

4.2.2 Scenario forecasting: Natural Gas Price

The analysis of the whole empirical framework has shown an uncertainty regarding the shale gas development. These days the exploration of shale gas is widely executed only in North America and the question is in which extend it will spread up worldwide. Thus two (2) scenarios could illustrate this issue. Firstly a low price scenario, with prices around the level of 3.5 $/mcf, based on an extensive exploration of natural gas which is related to the shale gas explorations outside of USA and Canada. The second scenario presents a more conservative approach of higher prices which are influenced from limited natural gas exploration as the shale gas developments may not go further in near future.

The following [Figure 28] shows the impact on global LNG vessels capacity if the price of natural gas increase with relatively low rate and between 3 and 4 $/mcf for the next 5 years. The slow growth of the commodity's price leads to a smooth decrease of global LNG ship tonnage.



[Figure 28] LNG fleet capacity forecast given a 3 to 4 $/mcf price of natural gas (source: author)

As it is not sure in which extent new gas fields or shale gas development will be utilized it is very possible to see a considerable, sharp increase of natural gas prices. The [Figure 29] shows the significant effect of this case on global LNG fleet capacity which decrease to in 2017 back to the levels of 2010.

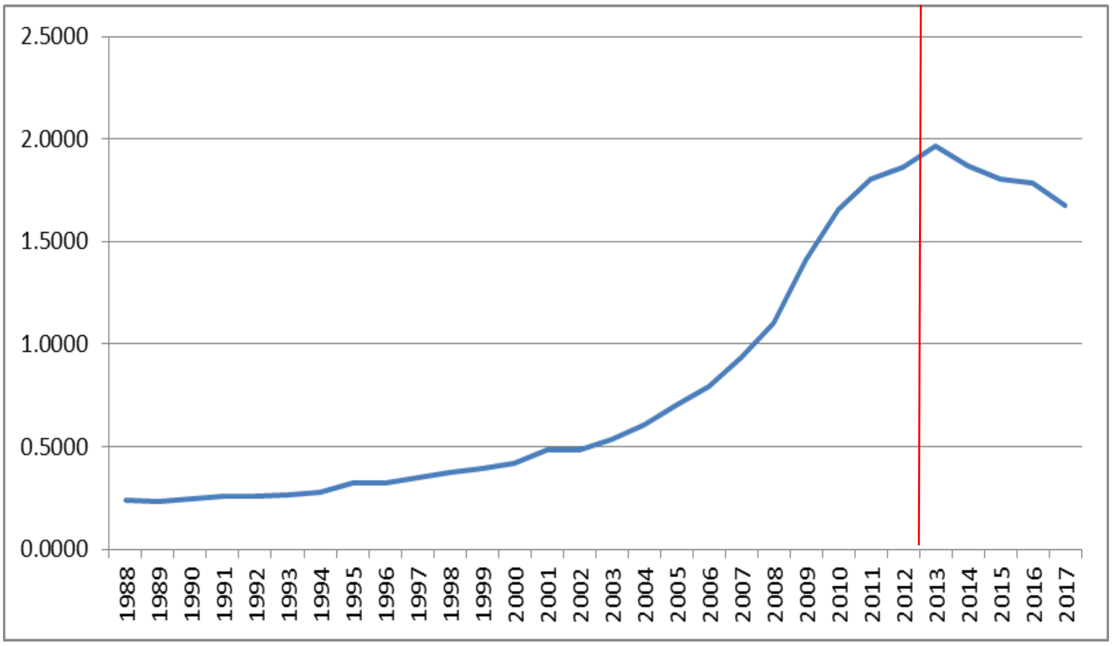


Figure 29] LNG fleet capacity forecast given a 6 to 7 $/mcf price of natural gas (source: author)

5. Discussion and Conclusion

5.1 Market Outlook

Natural gas used to be rejected product of oil production, these days it is a major source of energy. Liquefied Natural Gas (LNG) used to be considered an expensive method of commodity's transportation but current costs and the short-term predictions seem to diminish the concern of high expenditure, due to the infrastructure already constructed and that is being built.

A very dynamic combination of global events will boost the natural gas importance. The global population growth, by definition will increase the demand for energy and electricity in particular. On the other hand the upcoming legislations promote the green energy and try to limit CO2 emissions. Moreover the possible expansion of shale gas production will change the market as it is known today.

There is a fast growing LNG market including: pipeline, terminals and vessels. There is a great number of importers (buyers) and exporters (sellers) of natural gas, and the whole expanding network will led to the integration of the domestic markets to the global market.

The depletion of land gas fields will boost the deep-see exploration and production via FPSO facilities while the extensive offshore production in combination with the globalization of LNG market will drive the expansion of the LNG vessels.

Indeed there are many strengthens and bright future for the LNG vessels market: the growing demand for natural gas-LNG, the high newbuilding activity with relatively low prices, the long asset life (more than thirty (30) years), the dynamic potential of unconventional reserves of natural gas as well as the high barriers to entry as a good track record is required. On the other hand, there are few weak factors such as the small spot/short term market, the technological improvements which may reduce the life of the current modern assets and possible incidents which could severely impact the track record of the industry.

5.2 Evaluations and Suggestions

The results from the regression analysis come to confirm many of the statements which are presented in the Empirical Overview. Regarding the demand for sea transport factors such as the Global GDP per capita as well as political events which determine the oil and gas prices could affect the natural gas consumption worldwide and as a result the demand for sea transport and vessels capacity.

Thus, regarding the demand in a particular time the supply follows to adjust. It's very important to mention that in short term the supply of LNG ships capacity is not able to cover the demand; there is a time-lag. On the other hand, long-term there is a balance in the market until the next shipping cycle.

The model presents an relation among some variables which can indicate the available ships capacity in a given time. The analysis came with exceptional characteristics among the variables as the R indicator logged very high values while the model kept the appropriate statistical significance.

It is also worth to be mention that the shipping cycle theory is strongly related to the proposed model. If the market is under balance, to wit the supply of tonnage covers exactly the demand, all of a sudden because of a change in global economy the demand could sharply increase in short-term leading the market to imbalance. This particular change, exactly such as a political event, could boost the GDP per capita and therefore crude oil prices. According to the proposed model this phenomenon could probably have an impact on the global natural gas consumption and might urge the ship-owners to set extra orders for new building at yards. As a result from the massive orders could be the oversupply of capacity and thus the market could face the next shipping cycle. Hence, it could be argued that the model could provide a sense of the shipping cycle's analysis under a different point of view.

All the research studies in the sector of economics have their own weaknesses. Besides the omissions and failures of the researchers, the complex of the real world and economy is itself a great factor of error. Thus that complexity guarantees that none research attempt related to economics can covers all the possible variables which determine the particular phenomenon.

The main weakness of this study is the use of very limited number of variables in the proposed model. This has been imposed from inherent restrictions which are related to the academic level of an Master Thesis. The author, for first time, dealt with the methodology of academic research both in the theoretical and numerical part. Hence, it has been decided to keep the number of variables limited in order to archive the desired results on time. As a result the first suggestion for future studies is the model's enrichment with new variables, a situation which can improve the forecasting capability. Another suggestion is the examination of model's validity during different time periods.

At this point, it is valuable to be mention that this model does not aim to gain the title of the accurate forecasting tool for the LNG vessels capacity, as despite the time-lag between supply and demand the factor of the psychology of market players such as ship-owners, charters, banks etc. is critical and make shipping an unpredictable as well as charming business.

Through an extensive presentation of the major variables which influence the supply and demand for natural gas sea transport, a research model has been conducted. This particular effort was a real challenge for the author, who during the research period gained a valuable understanding of natural gas and LNG vessels market and enhanced his numerical capabilities. I hope that this thesis could be a trigger for further studies which will probably provide an accurate tool to the shipping industry.

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