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The gas market and LNG shipping in transition : the potential impact on the Algerian LNG industry.

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THE GAS MARKET AND LNG SHIPPING IN TRANSITION

The Potential Impact on the Algerian LNG Industry

By

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In

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(SHIPPING MANAGEMENT)

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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"LIQUEFIED NATURAL GAS (LNG) IS EXPECTED TO PLAY AN INCREASINGLY IMPORTANT ROLE IN THE NATURAL GAS INDUSTRY AND GLOBAL ENERGY MARKETS IN THE NEXT SEVERAL YEARS. THE COMBINATION OF HIGHER NATURAL GAS PRICES, LOWER LNG COSTS, RISING GAS IMPORTS DEMAND, AND THE DESIRE OF GAS PRODUCERS TO MONETIZE THEIR GAS RESERVES IS SETTING THE STAGE FOR INCREASED GLOBAL LNG TRADE"

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ABSTRACT

Title of Dissertation: **The Gas Market and LNG Shipping in Transition.**
The Potential Impact on the Algerian Gas Industry.

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The world gas and LNG markets are witnessing an unprecedented growth within a short period of time. Technological development has considerably reduced the costs of gas and LNG projects enabling this fuel to enter in competition with crude oil and coal. The world community exigencies also force the world industry towards gas consumption by trying to implement stiffer regulations since it is considered as an environmentally friendly fuel. Consequently, significant gas and LNG projects are now being under construction and a promising gas and LNG trade is expected in the future involving both the traditional gas suppliers to play in the LNG market and new players to inscribe their names in the list of gas and LNG suppliers and consumers.

The commercial transactions of gas and LNG are also seeing transformations. The contracts are being short and flexible and the gas price mechanisms are changing. The propensity of buyers and sellers towards the gas and LNG spot market has been noticed recently and experts foresee its growth in the upcoming years, inclining to acquire the same patterns in transactions seen in the oil market. The pros and cons of this market are evaluated differently from buyers to sellers according to their interests and its evolvement will depend on many parameters and variants that may change in the short and long run.

This thesis is a study of the evolution of the gas market and LNG shipping. It aims to give an in-depth analysis about the development of the gas and LNG spot market and its future by making a comparison with the oil market taking into account the likely changes in the ages and LNG market in the long run. It also aims to assess the benefits and risks for buyers and sellers in general and for the Algerian gas market in specific.

Key Words: Gas, LNG, spot market, long-term contracts, short-term contracts, benefits, risks, and uncertainties

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LIST OF ABBREVIATIONS

Bcf	Billion Cubic feet
Bcm	Billion cubic meters
CBM	Coal Bed Methane
CIF	Cost Insurance Freight
CNG	Compressed Natural Gas
DES	Delivered Ex-Ship
DQT	Downward Quantity Tolerance clause
E&P	Exploration and Production
EPC	Engineering, Procurement and Production Contract
FOB	Free On Board
FPSO	Floating Production, Storage and Offloading.
FSRU	Floating Storage Regasification Unit
GECF	Gas Exporting Countries Forum
GTL	Gas to Liquid
HH	Henri Hub
IOC	International Oil Company
JCC	Japanese Crude Cocktail
LFG	Land Field Gas
LNG	Liquefied Natural Gas
MMbtu	Million British Thermal Units
MMtpa	Million Metric tons per annum
MSA	Master Sale Agreement
NBP	National Balancing Point
NG	Natural Gas

NGH	Natural Gas Hydrate
NGLs	Natural Gas Liquids
NOC	National Oil Company
OPEC	Organization of the Petroleum Exporting Countries
PEC	Price Escalation Clause
PFHE	Plate Fin Heating Exchange
PLNG	Pressurized Liquefied Natural Gas
PRC	Price Review Clause
PSM	Price Sharing Mechanism
SPA	Sale and Purchase Agreement
SRV/LNGRV	Shuttle/LNG Regasification Vessel
Tcf	Trillion cubic feet
ToP	Take or Pay

CHAPTER I
INTRODUCTION

1.1 General Overview

The international trade of natural gas has witnessed a rapid growth during the last decade and many experts foresee the gas market to continue to grow fast in the upcoming years. Natural gas becomes the fuel of the 21st century for its dual advantages of being an environmentally friendly and relatively cost-effective fuel. Compared with the industry of the 1970s and 1980s, the gas sector has recently recognized transitions mainly in three aspects namely: technical and economic performance, infrastructures and routes development, and commercial transactions. In contrast to the first and second domains, which are straightforward and unchallenging to both gas producers and consumers and are positively supporting the development of the gas market, the changes in the commercial aspect, however, show several ambiguities and risks in the price volatility, in the balance between demand and supply and in financing projects, which perhaps lead to negatively affecting the gas production and consumption.

The first transition in the gas market is discerned in the technological breakthrough. Technology was the most decisive parameter that enhanced gas projects in the past and its efficiency remains very sensitive and doubtful to the development of the gas industry in the future. Gas projects which were difficult or even impossible to realize in the past are now eased by modern means, and this has helped significantly to reduce the costs in exploring and transporting conventional gas. In fact, today the conventional gas is the only popular source that shows efficiency in trade compared with other nonconventional gas. However, it appears that many other types of gas reservoirs are available worldwide to compete with this traded gas and their probable development in future may change considerably the current chart of the gas market and LNG routes. Technology may also go in favor of non-gaseous energy by improving their cost-efficiencies to the detriment of gas development.

Even though technology has considerably reduced gas transportation costs, the current efforts to look for the most cost-effective way in transportation, are proving the discontentment of the gas industry with the relatively high costs and the limitations resulting from the traditional way of conveying gas. A lot of studies are being developed and promoted by different national and international oil companies (NOCs and IOCs) to improve the way of transporting gas. Any new upgrading in transportation can change the current paradigm of the gas market that has been usually effectuated through pipes or cryogenic vessels.

The second transition in the gas industry is seen in the high dispersion of gas infrastructures and in the changes in LNG routes. Along with the development of pipeline projects, LNG infrastructures promise a high increase in gas production and consumption. Some of the traditional gas suppliers by pipelines are planning to invest for the first time in the LNG market. New gas consumers and producers have already penetrated the gas market and others show a potentiality in trading LNG. Moreover, cross trading shipping routes are developing to link the Atlantic Basin market with the Asian Basin. Under this changing environment, Algeria is trying to contribute to the gas trade development, first, by exploring more gas reserves and building more pipelines and LNG infrastructures, and second, by expanding the distribution of its gas towards both basins. The new strategy in cooperation with IOCs has fostered the Algerian objective of being among the countries which are now playing an important role in the balance of world gas demand and supply.

The third perceived transformation is manifested in the different changes in managing gas projects and LNG shipping and in the contractual transactions. Recently, unbundling gas projects is a tendency of new suppliers and consumers to achieve flexibility in the trade. As a result, shortening gas and LNG contracts comes to ascertain the necessity of this flexibility in order to provide some benefits to both buyers and sellers. The management of LNG ships has also started to change accordingly by allowing them to operate in a speculative market.

In addition, changes in regulations have enhanced the trend towards the spot market and gas consumption. First, liberalization and deregulation in the gas sector have enticed gas communities to operate in the gas spot market by changing the gas price mechanisms in an environment of high oil prices and gas-to-gas competition, influencing prices to move downward. Second, the international environmental regulations and pressures from national communities are changing the way of thinking of certain energy consuming countries by indirectly forcing them to turn to gas consumption.

In fact, these transformations in the gas sector give the impression that the gas market is moving towards a market with similar functions as that of oil. Many similarities evoke this trend, but opposing forces in the inherent gas market are acting in the opposite direction. The extent to which the development of the gas and LNG spot market will evolve in the future can be perceived by simply making a comparison between the oil and the gas markets and by identifying their constraints.

With the favorable new environment in the world gas market, Algeria recently has taken a decision to shorten its gas sale contracts to take advantage from arbitrage by operating in the short term/spot market. However, the risks from this uncertain market can greatly affect the development of its gas trade, its new gas projects and even the whole economy of the country. Under the pressures of the world market economy, the national LNG shipping can also be influenced in the way that they may be forced to operate without protection from the national oil company as it was usually the case in the past. These risks have to be evaluated in depth in order to demonstrate the validity or fallacy of the Algerian new strategy in the spot market and to determine how it can influence both the relationship with its traditional customers and the fate of its gas market and LNG shipping.

1.2 Objectives

Natural gas and LNG markets are expanding following the expected high demand growth coupled with structural changes within the market. Although important studies have comparatively analyzed the impact of the growing gas and LNG spot market on consumers, little academic research has been done to scrutinize the effect of these changes on suppliers. Moreover, little has been done in the subject taking into account the actual economic recession as an additional parameter that may affect the trend of the gas and LNG market. These new aspects have been the main locomotives of the author to present a large selection of research opportunities, and to allow the reader to be in touch with the recent developments of the gas and LNG markets that would be of academic interest.

The dissertation is a sincere approach that contributes to the knowledge of the gas and LNG markets by covering all the issues regarding the contemporary development of gas products and transportation in conjunction with the economic performance, the expansion of the market with regard to infrastructures and routes, and the changes that are currently noticed in gas and LNG trade. This thesis also seeks to showcase the different benefits and risks in operating in the spot market. A case study of Algeria has been selected in this paper since it is the only gas producer which has publicly declared its intention to fully operate in the short-term/spot market. This research, therefore, concentrated on answering the following research question:

- To what degree will the gas and LNG spot market develop and what is the impact of the Algerian new strategy on the development of its gas market and on its national LNG shipping?

In order to answer this question, four objectives have been introduced, namely to

1) showcase the role of technological advances in changing the fate of the gas market in general and the LNG spot market in specific;

2) determine the trend of the LNG spot market in the upcoming years including the LNG shipping by trying to:
   - elaborate a comparison between the gas and oil markets
   - identify volume risks by predicting scenarios in gas demand and supply in the short and long term ;
3) present the Algerian gas and LNG markets and indentify the potential risks that Algeria may face in the spot market;
4) determine the potential risks in the Algerian national LNG shipping operating in the spot market environment and under the pressure of the world market economy

1.3 Research Methodology and Structure of the Dissertation

The methodology used to achieve the above objectives requires the amalgamation of the quantitative and qualitative analysis, which relies on research, statistics and inductive reasoning. The process in this study consists of collecting and presenting facts expressed by data, processing and illustrating this data into different tables and figures in order to facilitate legibility, analyzing and interpreting these different facts, parameters and variables, reviewing all the relevant contemporary events, exploring the experts' opinions and analysts' predictions, and synthesizing all this data so as to be able, first, to elaborate a comparison between the gas and the oil markets, second, to predict different demand and supply scenarios in the future, and last, to reach an inductive conclusion about the Algerian gas industry and the fate of the gas and LNG spot market in general.

The dissertation is presented in six chapters. Chapter one is the introductory chapter to the dissertation. Chapter two will consider some basics of gas and LNG and will emphasize on the role of technology in developing the conventional gas and LNG markets with regard to the environmental and economic feasibility of other types of energy, including nonconventional gas. It also focuses on the development of gas and LNG transportation and the struggle of the gas community to find and promote the most cost-effective way to transport gas. Chapter three presents the current development of the gas and LNG infrastructures with a prediction of the evolution in the short and long run. Through the chapter an analysis will provide different LNG routes that exist and the likely interlacing of the Atlantic and Pacific markets. This will be followed by a special look at the Algerian gas pipelines grids and LNG routes with a potential infrastructural development which is spurred by foreign co-operation.

Chapter four will examine the evolution of the gas and LNG spot market driven by several requirements from buyers and sellers and by analyzing the different changes observed in the gas markets. The future evolution will be assessed in this chapter by comparing the gas and oil market. Chapter five will assess the different opportunities and risks in the spot market by elaborating different scenarios in demand and supply, by focusing specifically on the potential risks for the Algerian gas industry. In the light of the world market economy and the pressure of the EC on the Algerian policy, this chapter will pinpoint the potential risks that Algeria may face in its national LNG shipping. Chapter six will provide the main findings of this study and some recommendations for the Algerian gas transactions.

CHAPTER II

INTRODUCTION TO NATURAL GAS AND LNG

Technical and Economic Development

2.1 Introduction

Many energy sources that exist naturally in different forms are abundantly ready for exploitation while technological breakthroughs come to ease their extraction and their transportation by reducing costs. Today, it feels that natural gas use starts challenging the development of other types of energy, and its future stimulus seems to rely much more on what technology can promote to reduce costs in the production and transportation.

Traditionally, natural gas was transported in its crude state only by the means of pipelines, but many techniques emerged allowing gas to be transformed into liquid and solid looking for the most cost-efficient way to transport it. Also in the production, the advances in technology have drawn the gas price to go down supported by the economy of scale, the development of materials and equipment, and new techniques in research.

In parallel, many other forms of gas contained in different reservoirs pop up to compete with the conventional natural gas. As a result, it appears that the future development of LNG and the conventional gas markets are not only tied to what technology can provide to them, but in relation to what it may contribute to the development of other gas form products. So, it is quite important for a better understanding of the gas and LNG market trends and their commercial aspects to put a light first on the contemporary technical evolution in gas and LNG and examine the role that technology can play in the future in offsetting their demand.

In doing so, first describing the progress of natural gas and LNG markets through history followed by giving general concepts, this chapter will provide a comprehensive analysis of the effect of technology and some emerging issues on the costs of producing and transporting gas, and discuss the technical motives for stimulating the gas choice compared with other types of non-gas energy. In addition, it will discuss the actual and potential competition between LNG, natural gas and other new emerging gas products as an introduction to comprehend the evolution of the gas and LNG markets scrutinized further in this paper.

2.2 Evolution of Natural Gas through History

Since the earliest recorded history there have been accounts of natural gas seeping out from the earth's crust in Iran between 6000 and 2000 B.C. A famous legend narrated that a man noticed a "burning spring" and realized that a non-visible, combustible, source issuing from porous rocks, was the origin of an eternal flame once ignited by occurrences such as lightning strike. People of the earliest civilizations were so bemused by these fascinatingly undying fires that Indians, Persians and Greeks ascribed them to divine nature and built temples at these sites to be reverenced and worshiped (Natural gas, 2009).

The succeeding generations with less superstition and more innovation discovered the potential utility of gas. The first gas use is attributed to the Chinese as early as 900 B.C by forming crude pipelines out of bamboo shoots to transport gas and using it for cooking and boiling seawater to get drinkable water (Nersesian, 2006, p.229).

By realizing its great benefit, the Chinese searched for gas and drilled the first well of 150 meters in 211 B.C, which testifies their insistence in exploiting gas and demonstrates their expertise in this activity centuries before the first gas apparition in Europe in 1659. Even though gas use in the United States of America was noticed earlier than in Europe, this went back only to 1620 when French missionaries reported that Indians ignited gases in the shallows of Lake Erie in New York State and in the streams flowing into the lake. Then, following the invention of the gas lighting system by William Murdock in the early 1790s, natural gas started competing with the industrialized coal gas to acquire in the USA for the first time a commercialized aspect when it was transported from the wellhead in Fredonia, NY for lighting houses in 1826. Following this event, it was used in industry to evaporate brine to make salt in 1840 (Overview of Natural Gas: History, 2004).

The growing benefit of this energy at the end of the 1800s and the start of 1900s urged the Americans to search for more gas and to develop a way to canalize it to further places with more efficiency and profitability. Indeed, a new era in the industry of natural gas came when Edwin L. Drake dug the first well and hit oil and natural gas near Titusville, PA in 1859. A five and half mile gas pipeline running from the well to the village was built proving that natural gas could be brought safely from its underground source to be used for practical purposes. The introduction of gas-firing appliances to the public such as stoves, water heaters, and burners fueled with gas stretched its consumption to reach 120 miles; one of the first lengthy pipelines built between Indiana and Chicago in 1891. Nine years later, with the internal combustion engine evolution and new well discoveries, compressors allowed moving gas farther distances forming niche networks of natural gas within 17 states (The official website for the city of Mesa, Arizona, 2009). However, the elementary technique to transport natural gas was inefficient at that time. It was not until the 1920's that a noticeable effort was put to improve pipeline infrastructure. Welding techniques, pipe rolling, and metallurgical advances after World War II allowed for the construction of reliable pipelines that led to creating thousands of miles of pipeline in America (Nersesian, 2006, p.232).

Once the transportation of natural gas was possible, the spreading of natural gas use in industry and residential application started seeing growth, especially in heating boilers used to generate electricity. The transportation infrastructure made natural gas easier to obtain rendering this energy a magnet for its exploitation.

2.3 General Overview of Natural Gas

2.3.1 Description of Natural Gas

The naturally occurring gas is sometimes informally called “gas” for short, but this may lead to confusion as it can be understood as gasoline. It is a colorless and generally odorless fuel that is directly used in heating and electricity. It is neither toxic nor poisonous and dissipates rapidly as it is lighter than air.

Natural Gas is composed of a mixture of different gases, but almost entirely of methane (CH4). There is always a small percentage of heavier hydrocarbon molecules such as ethane, propane and butane, whose level varies depending on where the gas comes from and how it is processed. These variations in turn affect the temperature at which the gas turns to liquid: known as hydrocarbon dropout.

With very few emissions, it is considered the cleanest fossil fuel because of its clean-burning qualities. Today, gas serves homes and businesses all over the world and has become most popular because of its comfort, ease of use and efficiency.

2.3.2 Origin and Location

Natural gas is often referred to as a nonrenewable fossil fuel that is trapped in porous rock deep underground. Scientists came to a conclusion that tiny sea animals and plants died 200 – 400 million years ago and sank to the bottom of the oceans where they were buried by layers of sediments and solidified into rock. Subjected to pressure and heat of the earth, the organic mixture gradually decomposed through thousands of years to form oil and gas encapsulated in the layer rock.

There are many types of sources for gas where it is naturally produced. Beside the conventional wells, nonconventional and renewable gas is two other forms of natural gas. Coal bed methane (CBM), a non-conventional gas found in seams of coal, is mainly localized in the United States, Canada, and Australia. Two other similar sedimentary reservoirs for this non-conventional gas are shale and tight gas which today acquire a great potential development in the USA and Canada as well. In contrast with natural gas reservoirs, the renewable landfill gas (LFG) is also a source of gas that comes from decaying garbage and it is usually burned in landfills to generate electricity. Once the technical challenges have been overcome for any of these gas sources, great potential to commercialize the unconventional gas and at lesser degree for renewable gas is possible on the international arena since much research has done to extract it efficiently, and now its exploitation is operated at the advanced stage in the U.S.A (Perry & Lee, February 2007; Trends in Unconventional Gas, 2008).

Another source of natural gas is shaped in combustible ice: a crystallized solid created during the interaction between methane and water in a high-pressure, low-temperature environment. It is found abundantly in the continental shelf and beneath high-latitude permafrost. While methane hydrate provides many advantages such as its green nature and also its smoothness for transportation which allows a reduction in shipping cost by 25% (Gudmundson & Børrehaug, 1996), technology remains limited to extract it safely with lower production costs (Liu, 2006).

2.3.3 Processing of Conventional Natural Gas

The consumption of natural gas in the rudimentary state is not feasible with stringent standards of cleanliness as far as it contains impurities and other heavy natural gas liquids (NGLs). Before it reaches consumers, natural gas is processed i.e. cleaned, from contaminants such as vapor waters, carbon dioxide, hydrogen sulfide, nitrogen, oxygen, and helium (See Appendix A). Also, once extracted from gas or oil and gas wells, natural gas has to be purified from petroleum gases such as ethane, propane, and butane before it can be safely delivered to high pressure. Although the processing is generally effectuated at remote producing regions where it is transported by gathering pipes, it is sometimes accomplished near the wellhead.

2.4 LNG Fundamentals

2.4.1 Development of LNG

Prior to the development of liquefied natural gas (LNG) technology, its transportation was limited to movements that could be served by pipelines. The successful experiments of the British chemist and physicist Michael Faraday with liquefying different types of gases including natural gas and the development of the compressor refrigerator machine in Munich in 1873, introduced first by Karl van

Linde, were behind the first commercial liquefaction plant built in Cleveland, Ohio, in 1941. Eighteen years later, the idea of conveying this odorless and colorless fuel overseas at about -163 degrees Celsius (256°F) brought the industry effort to convert the World War II Liberty freighter, the Methane Pioneer, into the first LNG tanker carrying liquefied natural gas from Lake Charles, La., to Canvey Island, the United Kingdom. This demonstrated for the first time that low density natural gas can be transported safely across the ocean efficiently in large quantities of liquefied natural gas by shrinking it 600 times.

As a result, the business of exporting natural gas overseas was triggered when the first exportation of Algerian gas to the United Kingdom occurred in 1964 making the United Kingdom the world's first intercontinental LNG importer and Algeria its first exporter. Since then, the trade of LNG has experienced a great success between Africa and Europe. With the improvements in technology and costs, the market for LNG spread out to other European countries and North America by building more facilities to produce, transport, and receives gas in liquid form.

2.4.2 LNG Value Chain

To make gas available to areas which are too distant to be reached by traditional pipelines, different units have to be implemented at each stage of the LNG chain process (see Appendix B). This involves huge investment in every step along the linked and dependant operations that need to build a complex of production, pipelines to conduct gas, liquefaction facilities, double hulled cryogenic specialized vessels and regasification and storage plants. In addition, the process of exploration is usually integrated in the value chain which incurs costs during the search for natural gas in the earth’s crust.

The LNG value chain cost has recognized two phases from the 1980s to 2007. In the first period until 2002, the value for a typical $5 billion LNG project dropped by almost a third due to the technological developments that have facilitated economies of scale along the long and complex LNG supply chain. This cost was estimated; however, in 2007 to be about 30 percent higher than the total value chain cost in

2002 (Foss, Jan 2007). The cause of this drastic increase in an LNG project cost is due particularly to higher raw material costs (especially steel). Probably today, it may have less effect as the economic recession has considerably driven down the price of steel. Figure 2.1 shows how the fluctuation of the value chain occurred in different elements of the chain process in the short and long run.

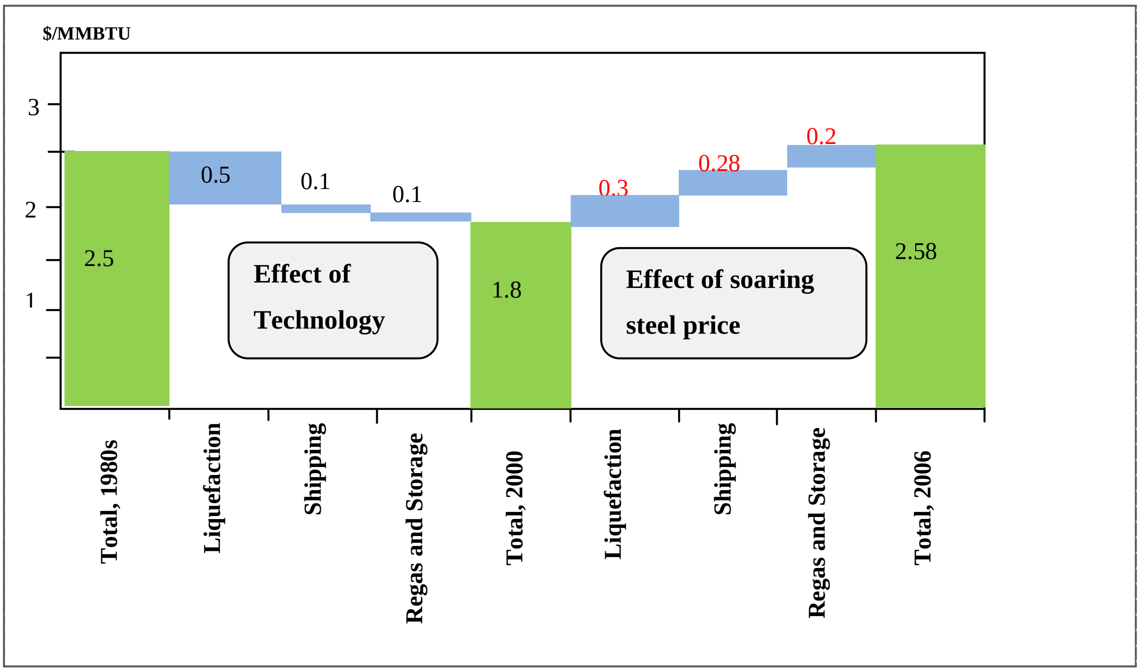


Figure 2.1: Changing costs in the value chain from the 1980s to 2006.
Source: Foss, M.M. Jan 2007.

The major part of capital investment in value chain cost is absorbed in the upstream projects where 80 % of the budget is dedicated to the production and liquefaction, including in some cases shipping facilities. For a typical LNG project, the cost can vary according to the countries' exploration and production, the pipeline infrastructure to the LNG terminal, shipping distance and cost. Usually, the number of ships required for LNG transport is limited by the annual capacity of the LNG production facility and taking into account the distance that separates the upstream from downstream countries. Generally, the shipping cost often varies between 15 to 25% of the total cost of the LNG value chain. Figure 2.2 illustrates the cost share in the LNG value chain that Tudor, Pickering, Holt & Co has published in their 2007 report (Nieuwodt, Febrary 2007).

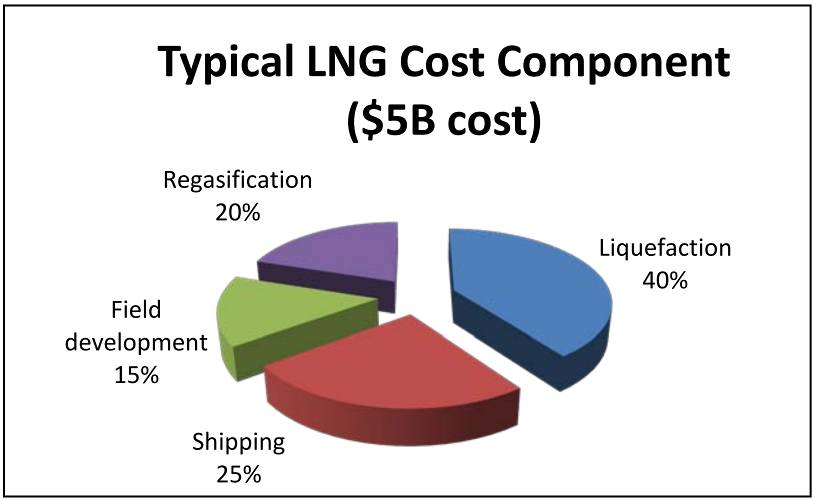


Figure 2.2: LNG cost Component in the LNG value chain.
Source: Nieuwoudt,S. February, 2007. Pickering Energy Partners.

2.5 Transportation and Storage Development

After being processed, natural gas is transported by different solutions to communities and other markets. The traditional method to convey natural gas from a processing field to consumers is basically done through a pipeline infrastructure network built to reach industrial regions or populated areas where gas is mostly used. The storage at this stage is not an issue as far as every house or factory is linked to the network, but the need to bring it to remote regions or to unconnected users evoked innovators to stock it in hard containers, at a normal pressure of 200–220 **bar** (2900–3200 psi), usually in cylindrical or spherical shapes in form of compressed natural gas (CNG). On the horizon, many shipping companies' projects to adopt this technique in transporting gas by introduced new Compressed Natural Gas Carriers (CNG vessels) trying to gain from the difference in transportation cost compared with LNG (ABS, 2004; Young & Eng, April 30, 2007) (see Appendix C).

Furthermore, due to the costs to reach more distant regions and with the introduction of liquefied natural gas (LNG), gas producing and consuming countries have realized the profitability to replace in some cases pipelines and CNG with LNG. Cryogenic vessels were built to carry this fuel overseas providing for the first time the connection of the European and North American continents with the shipment in

1959 and later with the shipment of first intercontinental commercial gas between Algeria and the U.K in 1964. Recently, many trials on LNG have been made to improve transportation performance and costs principally evoked by ExxonMobil (Fairchild et al, 2005) by carrying LNG in a pressurized environment (PLNG) at low temperatures of approximately -60 degrees Celsius instead of -163 degrees Celsius.

For the same economic reasons, two other physical forms of natural gas have emerged these days for studies in order to come up with the best solution for domestic and industrial use. The first form is produced with gas-to liquid or GTL technology by introducing synthetic liquid fuels that have actually experienced an impressive development by Shell, the leading company in GTL. The GTL industry has come a long way in a very short time after building the first plant in Malaysia. Shell expects to finalize the second, ten times bigger GTL complex in RasRafa in Qatar by the end of the decade that can reach 140,000 barrels of GTL products and 120,000 barrels of oil equivalent of natural gas liquids per day.

The other transformation technique of natural gas presents gas in sherbet form by the gas-in-ice process, which was first demonstrated by Norwegian studies and developed later on by the Japanese. Natural gas hydrate (NGH) is a form of natural gas trapped in water ice molecules. It contains 170 times as much as its volume of natural gas and can preserve itself well at -20° Celsius and at atmospheric pressure. NGH is expected to be a very safe, cost effective and environmentally friendly new medium for the transport and storage of natural gas (see Appendix D). Converting natural gas to NGH pellets also appears to be a promising technology for development of small-to-medium scale natural gas fields. Actually, the Japanese company Mitsui is leading the establishment of the NGH industrialization chain including production, transportation, storage and re-gasification.

As a conclusion, it can be assumed that the transportation and storage of natural gas has not yet achieved perfection since many gas industries are revealing in their own studies the importance of switching to other new forms of gas transportation. It is their way to show that the traditional methods of transporting gas by pipelines and

LNG are still generating high costs and present limitations in development that need to be replaced by new solutions to attain better transport and storage efficiency. Trying to promote and develop new products may, however, create competition in the potential variety of gas forms that may exist in the near future and thus, will influence primarily the production of LNG. Table 2.1 illustrates the new products of gas that may compete in the future with LNG in the production and in the traditional method of transportation promoted by different producing and gas shipping companies. The concept of transportation gas is shown in Appendix E.

Table 2.1: Potential competing gas products to LNG production and transportation.

Promoting company	**Statoil, Teekay shipping and Höegh**	**Shell**	**Mitsui**	**ExxonMobil**
Technique used	**CNG** **Can compete with LNG production**	**GTL** **Can compete with LNG production**	**NGH** **Can compete with LNG production**	**PLNG** **suitable LNG vessels needed**

2.6 General Technical and Economical Considerations

In the past few years, high and volatile energy prices, a surge in power plant construction costs, increasing pollution inquiries, and potential carbon costs have all contributed to the creation of urgency about the need for energy efficiency. As an effect, it has driven the affected community to decide whether it is economically profitable to lean towards the use of gas.

This indeed underscores the need for timely and in-depth analysis of the rapidly changing global gas industry comparing it with the development of traditional crude oil or other new forms of energy, such as renewable energy. The range of different gas products in their three physical states plays an important role to increase the use of gas and to provide a competitive advantage in the gas choice; however, it may present risks to decline the consumption of natural gas in the future if its technological development is restrained, the cost of its production and transportation becomes higher, or other forms of energy appear to offset the beneficial balance.

The future breakthrough in production and transportation of NG, CNG, GTL, NGH, and LNG is the main factor that can spur or reduce their utilization. The creation of competitiveness between these forms of energy will be enhanced by the potential opportunity that technology will offer to one type of gas to the detriment of the other, and more precisely, on the cost-efficiency, which depends in energy price in the first place with relation to capital expenditure and thermal efficiency.

2.6.1 Gas as an Alternative to Other Sources of Energy

It is agreed that natural gas is a very reliable, efficient, and environmentally friendly fuel with widespread uses and applications and by many believed to be the most important energy source for the future. Nowadays, natural gas use recognizes unprecedented growth in power generation and industries over the past ten years where generators and machines are fitted for a diverse fuel mix, which consists of coal, natural gas, oil, nuclear and renewable energy to adapt to the short-term energy fluctuations.

There are many factors affecting the switch to gas in the long run rendering the analysis of the future for gas consumption more complex. One is seen in the residential demand, basically in heating applications and the other in commercial and industry demand in which prospects show a steady increase, mainly because of its energy efficiency compared with that of electricity and dirty fuels.

The electric generation demand is a feature that presents two edges in gas demand volatility in the long run. While the tendency to install natural gas-fired combined-cycle generation plants has an effect of increasing gas consumption, generators of electricity using other sources of energy reverse the gas trend demand. The other challenge in competition between these two sectors is expected from the outcome of the restructuration and liberalization of natural gas and electricity that recently has begun to infiltrate in the states' policies which may also lower the energy price. At the end, the lower the energy price the more desirable the source of energy.

Moreover, the environmental emission regulations and technological advances play an important role in determining the trend of gas demand. The world community has become more concerned with equipments running on dirty fuels in industrial factories and in electric generation plants that are actually mostly burning coal. Technological advancements will play a role in the future for the demand of natural gas from the residential and commercial sectors as well as from the industrial sector. Despite that many applications currently run with electricity, this does not prevent natural gas from competing with electricity in many common household appliances if future technology will generate enough opportunities to increase demand for natural gas. Many appliances are expected to make inroads into those applications that have traditionally been served solely by electricity. In the industrial sector, the same result is achieved if the development of technology makes the expansion of distributed generation, and combined heat and power units all on the right track.

Natural gas use in the transportation sector is expected to grow fast when recently still in its infancy. Stringent emissions standards are motives for industrial companies to move for natural gas powered vehicles, which present an enormous opportunity for cleaning up the emissions from this sector. In the maritime sector, the use of natural gas has not yet been targeted since the storage capacity is a hindrance to promote its use. However, the expected development of GTL may offer great attraction at a time when stiffer regulations are being introduced to reduce air emissions.

2.6.2 Impact of Technology on Pipeline and LNG Costs

What has been recorded in the past and what will be expected in the future is the reduction of capital investment required for gas transport infrastructure. In the next decade, technological progress, both for pipelines and LNG facilities, will offer the opportunity to lower the costs, and this mainly results in reductions in future gas transport costs, particularly sensitive on long distance connections.

In addition, the upgrade system of 3-D (three-dimensional) and 4-D seismic imaging (see Appendix F for more details), which allow detailed complex imaging of rocks below the earth's surface, drilling and completion of complex well architectures using multi-branched well architecture, and "intelligent" completion systems and improved subsea facilities have reduced costs in the exploration and production activities (Natural Gas - From Wellhead to Burner Tip, 2004). The advances in technology will certainly provide more in this sector in the years to come with the expected sophisticated techniques that permit to gain more in investment and consequently, reduce considerably the price of the marketed gas.

Currently, pipeline technology has also seen an improvement in the quality of metal and better pressure endurance. High capacity onshore connections use steel grades up to X70 and operating pressures under 75 bars. Recent studies have concluded that by using higher steel grades (X80 and even X100) pressure levels could be increased to 140 bar, allowing for the same pipe diameter to transport a higher gas volume and make savings of about 20% in compression needs compared to current X-70 pipes (Cayrade, 2004).

In the LNG value chain, development has occurred in every stage. In the liquefaction plant, which is the most capital-intensive part in the chain, a 20% reduction in capital cost is expected by 2020, estimated by Patrick Cayrade in his report (Cayrade, 2004). This is principally due to the use of dual mixed refrigerants and high efficiency modularized plate fin heating exchange (PFHE). The success of using the Philips Cascade System (see Appendix G) in combination with these two techniques has demonstrated its efficiency in the Trinidad and Tobago plant, with the opportunity to gain more from the scale-up of ConocoPhillips Optimized Cascade Process technology in the future (Eaton, Hernandez, Risley, Hunter, Avidan & Duty, 2004).

Moreover, storage has always been an issue, particularly the problem of combining robustness with cheapness for a material selection. Nowadays, the effective way to reach this combination is by heavily insulating the storage tanks (see Appendix H). Nevertheless, when research in laboratories is bringing more benefit to the investment cost, the raw material price to build storage facilities has been soaring at the same time. Unfortunately, by contrasting with other energy stored in ambient temperature, LNG has to come a long way to compete with, for instance, oil in this activity since maintaining low temperatures still requires a considerable expenditure.

In ship transportation and the regasification plant, the same conclusion is achieved in reducing investment cost because of the technological advancement. New propulsion systems are aimed to replace the traditional steam turbine engines with smaller units that are more efficient which will not only reduce fuel costs, but will also increase cargo carrying capacity. The Q-flex and Q-max vessels developed recently are good examples showing that LNG ships become larger and more and more powerful. Enhanced tanker efficiencies provided with fuel consumption, safety, and longevity improvement have lowered shipping costs substantially. Shipyard expansions in the Far East and increased competition among shipbuilders have lowered LNG tanker costs by 40 percent from their peak (UHLC, January 2003).

Trying to find the best way to make LNG into vapor with fewer expenses, different methods have been used. Heating LNG by seawater, direct-fired heaters or through heat installations functioning with heated seawater are so far the best techniques used to reach cheaper investment. However, an 18% cost reduction was recorded not in the used technique itself, but attributed to competition among builders (UHLC, January 2003).

Whilst technology of building these four independent facilities have reduced costs considerably over the past 20 years by about 30 %, it is expected, however, to bring more positive results in the future trying to break the obstacles in the exploration, production and transportation and regasification operations once the integration of some of these different facilities into one unit is done. The development of the integrated units of the Shuttle Regasification Vessel (SRV), the Floating Storage Regasification Unit (FSRU) and Floating Production, Storage and Offloading (FPSO) are coming in force into the market to probably lower the gas price. In the next chapters, the development of these facilities will be more focused in an economical context to foresee their impact on the LNG market in the future.

2.6.3 Natural Gas vs. LNG Choice

The question of whether to transport gas by pipelines or in LNG by ships over long distances depends mainly on technical and economical factors, but the unpredictable political reasons, sometimes play a primary role in the choice. Consequently, there are no final standard prescriptions for selection and every potential project has to be considered as a particular case study for any investment decision.

Economically speaking, it appears that the cost to transport gas through pipelines is more profitable than in LNG until it reaches considerable transit distances. Some studies have estimated the equilibrium point between the LNG value chain and natural gas transport infrastructures to range between 4000 km and 6000 km for a single train that produces 10 to 18 billion cubic meters per year (Foss, January 2007; Jensen, 2004).

On the other hand, when it is a matter of more sizeable quantities, pipeline utilization in long distances may have some advantages that LNG applications cannot compete with. However, this comparison also remains theoretical as far as the itinerary and length will vary according to the adopted technical solution (See Figure 2.3).

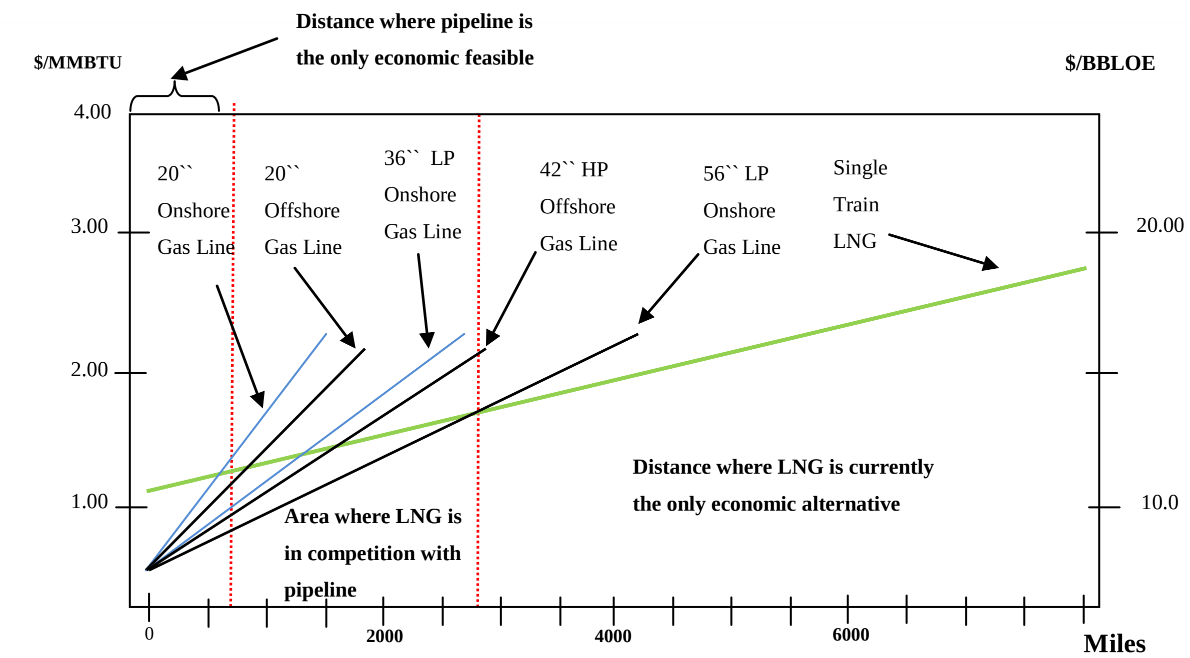


Figure 2.3 : LNG and Pipeline infrastructure costs.
Source : Jensen (2004).

Actually, it is generally assumed that the cost of pipelines is approximately 50% lower than those of LNG facilities in depths of less than 200 m, but costs can be multiplied by five if the depth goes beyond 500m. This has been recently largely reduced by the technological progress and caused the cost of LNG projects to start diminishing between upstream and downstream countries connected by deeper seas.

In contrast, the design of an efficient gas pipeline plan based on an economical and technical analysis may be abolished as LNG projects prevail as the only solutions in cases where geopolitical reasons impede the development of gas pipeline projects. Further in this paper, how geopolitics in pipelines influences the shift to LNG will be thoroughly analyzed.

CHAPTER III

ASSESSMENT OF WORLD GAS AND LNG MARKETS

A Special look at Algeria's Gas Development

3.1 Introduction

Natural gas is plentiful in supply and it is the fuel of the 21st century. The evocative description of gas growth has driven the world gas producers to boost exploration and production (E&P). Concurrently, new gas-producing countries have become aware of the benefit of marketing this fuel and started focusing their efforts on gas investments. The outcome of the glowing prospect has made the gas E&P and transportation chart to be continuously updated with extra centers and grids, which in the future, technological innovation can open up the opportunity of many more players involving many other old and new players with more loading and offloading options.

Along with the evolution of pipelines that becomes increasingly stretched on the earth's surface, LNG infrastructures in the upstream and downstream are multiplying even faster, but the limited LNG volumes beyond 2013 calls for the necessity to intensify the production to meet the foreseen demand (Gray, February 2, 2009a). The LNG trade is becoming more complicated and the fact that the eager consumers are far-away from the concentrated gas sources and the LNG projects are tightening the regional market.

Jensen (2003) analyzed in his article that the world gas trade has started changing from a simple intra-regional to a global market and that the LNG routes begin to intersect between the Pacific and the Atlantic Basins (Jensen, 2003). Many LNG routes have emerged to link the Pacific with the Atlantic because of the imbalance in demand/supply appearing when a rapid demand surge in a region occurs in the timing of incapability of traditional suppliers in this locality to satisfy this gas desire. However, many similar occurrences come to affirm the global gas under another concept of diversification and security of supply.

The advanced technology and reduction in costs have certainly optimized the gas trade and have revitalized the investments in gas. Nevertheless, the concretization of gas projects was effective by adopting a certain strategy when many state-owned resources had been kept frozen in difficulty to be monetized due to the scarcity of investment capacity in some countries. The opening up to foreign investments has created a new vitality in the gas projects and has given a new perspective in developing the government resources by being a facilitator rather than a builder.
In the frame of this world of gas environment and trends, Algeria has realized the necessity to adapt to the world gas restructuration by applying new notions in the gas E&P and transportation. Attracting investments and penetrating the downstream market have greatly driven Algeria to play an essential role on the international scene. Also, its strategic geographical position on the world map with its proximity to South Europe and its wealthy gas resources allow the country to play a leading role in the Mediterranean market without any genuine competitor and trying even to play an essential role in the Asian market as well.

Before analyzing in this chapter the development of the Algerian gas market, the potentialities to expansion and its role in the international scene, this chapter examines first the structure of the world gas market, the global main players in the gas sale and purchase and briefly summarizes the trends on the gas market. Then, will be analyzed the evolution of the Algerian market, its components, and the strategy followed by the government in developing its gas trade and infrastructures.

3.2 Trends in the World Gas Market.

World consumption of natural gas continued to rise in 2008 and is expected to grow fast in the future. This surge is more or less noticed depending mainly on GDP growth in the gas consuming countries. According to British Petroleum (BP)

Statistical Review 2009, a 2.5% change was recorded in 2008 over 2007 despite the economic recession that has affected many countries in the second half of 2008 (BP, 2009). The Energy Information Administration (EIA) stated in its Report that around 104 trillion cubic feet (Tcf) of gas was consumed in 2006 and consumption was expected to grow by nearly 50% by 2030 at a rate of 1.6% annually (See Appendix I J). Based on CEDIGAZ statistics, the trade movement of this abundant and attractant fuel, an economically effective alternative solution with relatively low environment impact (Black & Veatch, 2008), has increased by 74% over the last 10 years and almost tripled from 1990 through 2007 (CEDIGAZ, May 2008).

As the GDP growth in the non-OECD countries is expected to rise in the long run, using gas in these countries is projected by EIA to be more intensive (see Figure 3.1). China and India are potential gas consuming countries predicting together to soar from 3.4 trillion cubic meters (Tcm) in 2006 to 11.5 Tcm in 2030, followed by African countries with a growth rate of 3.2% yearly (EIA, May 2009a). In contrast, the OECD countries are expected to grow only by 0.9% and North America by 0.8% per year according to the same source.

Figure 3.1: World Natural Gas Consumption 1980-2030.
Source: EIA (from International Energy outlook May 2009).

The configuration of the natural gas trade has changed drastically since 1980. It happened when, on one hand, newcomers in natural gas production started operating in the gas market and more discoveries of gas were made in the long-established gas exporting countries, and on the other hand, the global appetite for gas as the fuel of choice attracted new gas purchasers to compete with the accustomed consumers for gas. The equilibrium between the demand and supply is preoccupying experts in the future as many gas suppliers are still presenting a great potentiality to boost their production and the possibility of the traditional gas pipeline servers to engage in producing and marketing the LNG, as is the case for Russia and Iran (Gray, October 21, 2008).

Traditionally, the balance in demand/supply between the three independent regions comprising a) the Americas, b) Europe, Africa, and the countries of the Commonwealth of Independent States (CIS), and c) the Far East and Middle East of the world gas markets limited for years their interconnectivity and each region developed its own distinctive supply/demand and pricing dynamics. However, the strong demand in the Pacific Basin, the cutoff of the gas supply of Indonesia, the security in gas imports, and the diversification policy of certain gas consumers have driven the gas market to stimulate the fusing of these markets into one market that leads to one pricing model.

The structure of the natural gas market is witnessing a mutation in the age of liberalization. Jensen (2003) affirms that the restructuration in the gas and electric power assumes basically that the traditional form of government monopoly operating the public utility of electricity and gas is inefficient and that competition inherently provides lower prices and more desirable service options for consumers (Jensen, 2003). The first experienced countries, namely the U.S.A, Canada and the U.K, to adopt this strategy found out that free market competition among buyers and sellers is the only solution to set commodity prices for gas (gas-to-gas competition). Today, the opening up of world gas markets to giant multi-energy companies, for whom natural gas will play a key role becomes a concept for European and Asian countries and is starting to be adopted in some African countries such as Algeria that plans to allow foreign participation even in the retail natural gas sector (EIA, May 2009b).

The technological development and the reduction of transportation costs are the main factors that preserved the world gas trade to develop in the right direction. They permitted exploration not only to double proven reserves in 2009, but they are also determinants in changing the simple and independent gas markets with few options for natural gas delivery to a market with wider coverage and more complex network. Furthermore, the flexibility in gas transportation in LNG has stimulated both intra- and inter-regional trade helping the gas-consuming countries which are concerned about security of supply by diversifying their gas import from a variety of sources. The International Energy Agency (IEA) Report (2007) states that LNG accounts for 70% of the growth in interregional trade since 2004, and LNG trade volumes are expected to more than double before 2015 (IEA, 2007).

3.3 Current World Natural Gas Environment.

Recently, the continual discoveries of natural gas worldwide have kept the proven reserves increasing by about 0.7% a year contrary to the common misconception that gas is running out quickly. EIA recorded in January 2009 that the amount of gas left in the ground which can be recovered in the future is estimated to be about 6254.36 Tcf compared with 6046.06 Tcf in 2005(EIA, May 2009a). This amount of gas is considered enough to supply the world with gas at the actual production rate for 62 years whereas the reserves/production ratio for oil is only 42 years with discoveries occurring at a relatively slower pace. The fear for the scarcity of oil under the ground and the increasing oil price sound the alarm of the importance of natural gas as a future viable resource and sensitize the energy consuming industries about the necessity to converge to natural gas unless other energy alternatives will pop up to offer better solutions, or further discoveries in oil will renew the hope in oil exploitation.

There is an abundance of natural gas in the world, but it is mainly localized in some regions that have the capacity and the means to satisfy the world needs in gas. Much of this gas is considered “stranded” because it is located in regions distant from consuming markets. Russia and Iran were usually considered the main important reservoirs of gas before the great finding of gas in Qatar at the start of the millennium, consisting together of more than 53% of the proven world gas reserves in 2009 (BP, June 2009). In contrast with the Russian Federation, which is the first producer and exporter of gas entirely by pipelines to Europe with 58.1Billion cubic feet(Bcf), Iran still has difficulty to efficiently exploit its resources where the production is almost dedicated to local consumption (see BP Statistical Review 2009). Today, the distribution map of gas reserves has changed this last decade to let Qatar gas exportations to play an essential role in feeding the East and West with LNG. Currently, Qatar has even started to penetrate the European and North American markets as the demand is steadily rising in these regions timing the inquietude of the European countries to run out their indigenous gas reserves in the very near future. Figure 3.2 presents the change in proven gas reserves in 2009 compared with reserves in 2000.

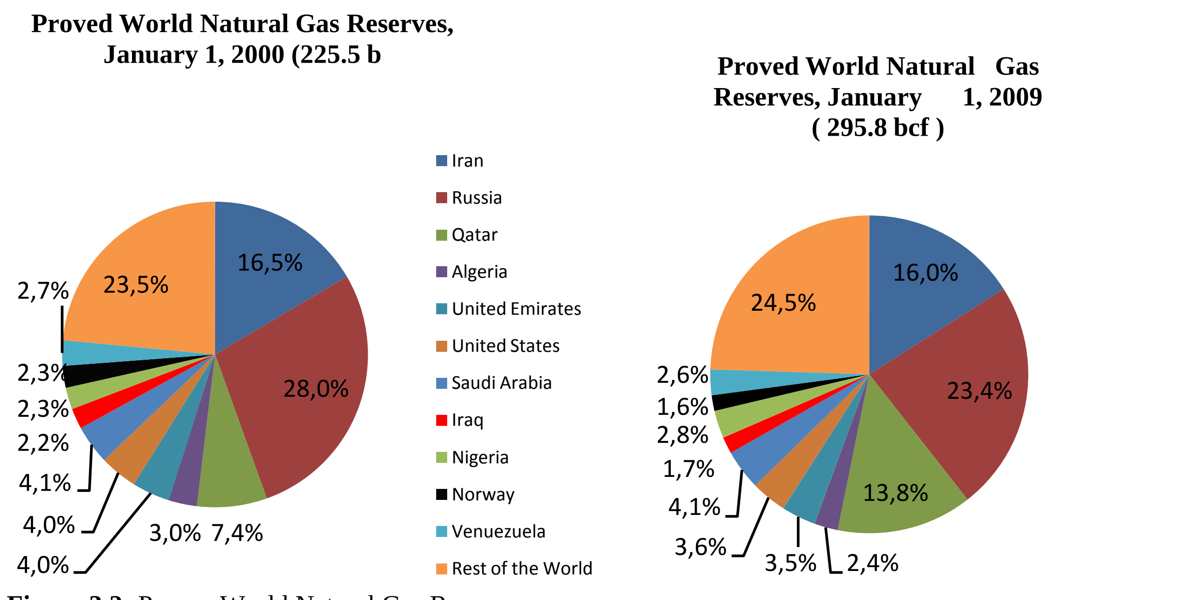


Figure 3.2: Proven World Natural Gas Reserves.
Source: Compiled from BP Natural Gas Statistical Review, June 2009.

Beside Qatar, the two important LNG suppliers in the Pacific Basin are Indonesia and Malaysia, which together supplied approximately 35% of the world's LNG consumption in 2003. However, the cutoff in the Indonesian gas supplies to Japan, the world's second largest gas consumer after the United States, reduced considerably its LNG exports to 11.8% of the total LNG exports at the end of 2008. Moreover, Australian LNG deliveries to South Korea, Japan and Taiwan reflect the weighty position of its LNG trade in the Pacific market tempting new consumers, namely India and China, to take profit of its gas resources. In addition to these three main gas-exporting countries in the Pacific Basin, the investment to extract gas in Iraq is still on the drawing board and the production in Saudi Arabia and Kuwait has currently not yet reached the exportation level despite their potentiality to sell their gas.

Some African gas producing countries, such as Nigeria and Egypt, have recently penetrated in force the LNG exportation to alleviate the tension on the traditional gas suppliers by pipeline towards Europe where gas is traditionally served mainly by Russia, Norway and Algeria. Similarly, the emergence of Trinidad & Tobago gas discoveries has dramatically restricted the dependency of the United States on the Asian and African LNG imports relying deeply on both the local production and the Canadian gas supplies by pipeline. BP illustrates the main pipeline network and LNG routes updated in 2007 as shown in the Figure 3.3.

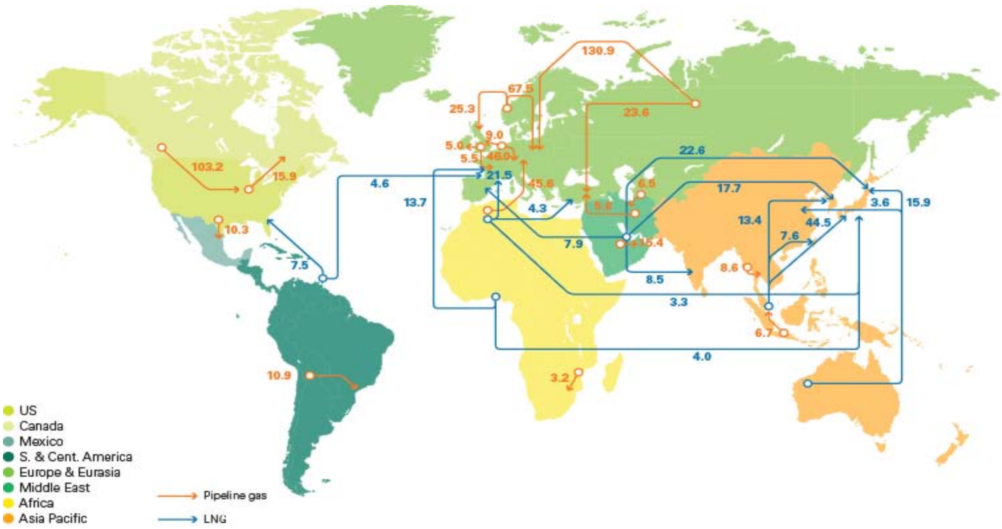


Figure 3.3: World Pipelines and LNG Routes in 2008.
Source: BP Statistical Review of World Energy, June 2009**.**

3.4 International LNG Market Structure, Prospects, and Potentialities

For a long time, the Atlantic market and the Pacific market were considered two separate markets. The Pacific market that comprises buyers in Asia Pacific (Japan, South Korea and Taiwan), India, China and the nascent markets of the North

American West Coast. Mainly, this market is currently supplied by liquefaction ventures in Malaysia, Indonesia, Brunei, the Middle East, Alaska, and Australia.

LNG ventures that supply the Atlantic Basin market covering European and North American buyers are North Africa, West Africa, The Caribbean, the Barents Sea and the Middle East. Long-term trade dominates regional markets despite the interaction of LNG trade of these two regions.

3.4.1 Global LNG Supply Sources

In 2008, the world was rich in liquefaction capacities that produce 188.9 million metric tons per annum (MMtpa) of LNG (see Figure 3.4). According to Barry Rogliano Sales (BRS), 50 million tons/year is expected to be added this year and around 550 million tons of total capacity will be operational in 2019 (BRS, 2009). Algeria, Nigeria, and Trinidad & Tobago are the -dominant leaders in the Atlantic basin, which leads the world's liquefaction capacity with 75.5 MMtpa (9.7 Bcf/day). Egypt has also shown recently its new entry in the LNG trade to inscribe its presence among the mature Atlantic LNG leaders in this market. In fact, among the big LNG suppliers, Algeria is the only country that has an experience of more than 40 years whereas Nigeria and Trinidad & Tobago are considered recently-developed exporters minimizing as such the Algerian LNG market power. Then, the Pacific Basin follows at nearly 67 MMpta with Indonesia, Malaysia, and Australia being the leading LNG countries. Finally, the inventory of liquefaction capacity in the Middle East is 46.5 MMtpa dominated by Qatar. Appendix J provides a current inventory of the capacity worldwide in 2007 and 2008.

Projects under construction show that an increase of around 53 % of the current world liquefaction capacity will be achieved by 2012. About 78% of these projects are planned to be operational by 2010 and near the half (47%) of this capacity is being built for Qatar.

What is noticeable in the projects which are under construction in the Atlantic Basin are two folds. First, Algeria will raise its LNG capacity by more than half by the end of 2012 and second, Angola will enter the LNG market, which will support the Atlantic Basin with more LNG players.

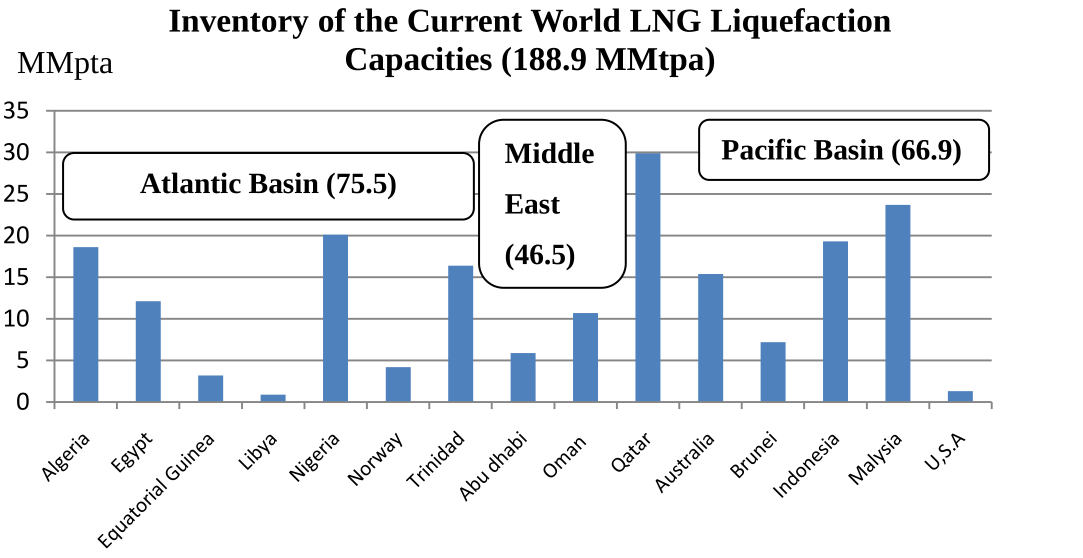


Figure 3.4: Inventory of the Current World Liquefaction Capacities as of March 2008.
Source : Benjamin Schlesinger and Associates. Compiled from Poten & Partners Data, Inc 2008.

Likewise, two other new players are detected in the forthcoming LNG suppliers in the Pacific Basin. Russia with its largest proven reserves and dry gas exporters by pipeline to Europe starts to adopt a strategy towards LNG trade with its first project being built at Sakhalin (9.6 MMPta). In 2010, the new Peruvian gas producer will join the world LNG supplier list that is continually inscribing newcomers.

Qatar has also imprinted its attendance on this list with a distinctive character. As pertaining to the Middle East, which is ideally located to serve both markets (Pacific and Atlantic), the appearance of Qatar in the LNG business has made the trade much more global. The Qatari investments in the LNG mega-trains with its partners will provide more flexibility of LNG trade in future towards European, U.S., as well as Asian markets, which are planned to start up in 2009 and 2010 (Benjamin Schlesinger and Associates, October 2008). Table 3.1 reiterates the major LNG suppliers discussed above with their likely projects in the short term.

Table 3.1:Liquefaction Projects under construction as of March 2008

Country, Plant Name	Expected Start Date	Nameplate Capacity, MMt/y (Bcf/day)
Atlantic Basin		
Nigeria LNG	2008	4.2 (0.5)
Algeria – Skikda	2011	4.5 (0.6)
Libya – Brega	2012	3.2 (0.4)
Angola LNG	2012	5.0 (0.6)
Algeria – Gassi Touil	2012	4.7 (0.5)
Subtotal, Atlantic Basin		*21.6 (2.6)*
Middle East		
Qatargas II	2008-2009	15.6 (2.0)
Yemen LNG	2009	6.7 (0.9)
Qatar – RasGas III	2009-2010	15.6 (2.0)
Qatargas III	2009-2010	7.8 (1.0)
Qatargas IV	2010	7.8 (1.0)
Subtotal, Middle East		*53.5 (6.9)*
Pacific Basin		
Russia – Sakhalin LNG	2009	9.6 (1.3)
Australia NWS	2008	4.4 (0.6)
Indonesia – Tangguh LNG	2009	7.6 (1.0)
Peru – Camisea	2010	4.2 (0.5)
Australia – Pluto	2011	5.0 (0.6)
Subtotal, Pacific Basin		*30.8 (4.0)*
Total, All Basins		***101.2 (13.0)***

Source: Reported by Benjamin Schlesinger and Associates from Poten & Partners Data 2/2008.

LNG projects that are more or less in advanced planning but not contracted (engineering, procurement and production contracts (EPC) have not been signed yet with sponsors) are promising for more supplies. Table 3.2 shows that the projects in Nigeria in advanced planning stage will support the Atlantic with 40.5 MMtpa in 2018 through 4 successive projects whereas Australia will add with its 2 planned projects 24 MMtpa. An additional 64.5 MMpta at the end of 2016 is expected to supplement the world LNG supply.

Other potential additional supplies are expected in the years to come. The major traditional power in the Middle East and in the Atlantic and Pacific Basins in gas looks at the horizon with a very ambitious vision to face the strong gas demand and other new players such as Venezuela and Papua New Guinea may pop up with their first imprints in LNG.

Table 3.2: Global LNG Projects in Advanced LNG Stages.

Country, Plant Name	Expected Start Date	Nameplate Capacity, MMt/y (Bcf/day)
Atlantic Basin		
Nigeria LNG	2012	8.5 (1.1)
Nigeria – OK LNG	2014-2016	11.0 (1.4)
Nigeria – Brass LNG	2014	10.0 (1.3)
Nigeria – OK LNG	2016-2018	11.0 (1.4)
Subtotal, Atlantic Basin		*40.5 (5.2)*
Pacific Basin		
Australia – Browse LNG	2013-2014	14.0 (1.8)
Australia – Gorgon LNG	2014-2016	10.0 (1.3)
Subtotal, Pacific Basin		*24.0 (3.1)*
Total, All Basins		*64.5 (8.3)*

Source: Reported by Benjamin Schlesinger and Associates from Poten & Partners database

Other potential additional supplies are expected in the years to come. The major traditional power in the Middle East and in the Atlantic and Pacific Basins in gas looks at the horizon with a very ambitious vision to face the strong gas demand and other new players such as Venezuela and Papua New Guinea may pop up with their first imprints in LNG.

Russia is planning to reinforce its LNG supplies with two other projects; one in the Atlantic and the other in the Pacific. Australia is looking to dominate the Asian Pacific market with a prospect to surge production by 27 MMtpa. In the Middle East, Iran, the second richest country in gas is trying to monetize its resources to sell gas in form of LNG. The probable introduction of Iran with 27.1 MMtpa can make a difference in the equilibrium of LNG demand and supply in the mid-term and may threaten the power of Qatar in the region if the Iranian LNG projects will come into physical existence (see Appendix K for more detail).

3.4.2 Global LNG Demand Outlook

To prepare for the additional supply resulting from the liquefaction capacity projects, many countries and regions, including the United States, Canada, Europe, South America and Asia, have taken steps to boost investments in the development of import terminals. According to Platts, LNG regasification capacity is outstripping new liquefaction plants at a rapid rate (LNG regas capacity is outstripping, March 12, 2008). The low costs of regasification plants reflect this redundancy to achieve the followed strategy towards diversification that may create high competition in acquiring gas in the future with regard to the restrained liquefaction capacity.

3.4.2.1 Asia Pacific Basin

LNG volumes have usually been dominated by the Pacific Basin (see Figure 3.5) substantially by the three major Asia-Pacific consumers (Japan, South Korea, Taiwan), which contributed more than 62% of world traded LNG and more than 90% of LNG traded in Asia in 2008 according to CEDIGAZ (BP, June 2009). Almost all these quantities are directed to electric power generation. In this region, India and China have started as well to play an important role to divert some LNG to their domestic markets.

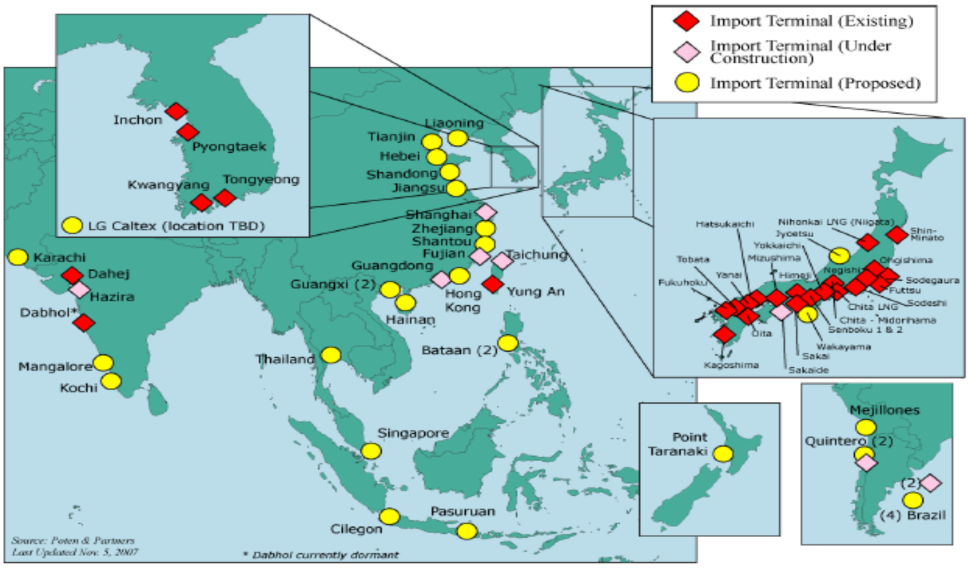


Figure 3.5: Asia-Pacific LNG Market.
Source: Reported Benjamin Schlesinger and Associates by American Gas Foundation from Poten & Partners, Inc 2008.

The LNG use in future in this region is set to be a promising strategy. In Japan, however, it is assumed that no significant LNG terminals will be developed until 2025 due to the slowdown in its economic growth and the drive to improve energy efficiency (price of gas is high). In contrasts, China and India will see an important growth in LNG despite the other competing fuel such as coal, which remains the cheapest commodity, and the possibility of supplying these two countries with gas by pipelines from neighboring courtiers such as Russia, Iran and Central Asia. HIS Global Insight observes the impact of China and India on the global LNG market to be uncertain and complex in the long run (HIS Global Insight, October 2, 2007).

3.4.2.2 Atlantic Basin

In the Atlantic Basin, Europe and the United States are in the midst of a period of rapid demand growth, with highly competitive procurement (Benjamin Schlesinger and Associates, 2008).Although the Atlantic Basin market was as old as 1964, the growth only commenced in 1999, when the Atlantic LNG (Trinidad) commenced operation with sales to Spain and the U.S., Nigeria LNG began LNG deliveries to European buyers, and Algeria ramped up production following completion of a major renovation of its liquefaction facilities. In Europe, Spain is the country that has long developed its policy towards LNG import. Today, more than 50% of LNG destined to Europe is absorbed in Spain bringing LNG mostly from Trinidad, Qatar, Nigeria, Algeria and recently Egypt; and with less volume from Libya, Oman, Equatorial Guinea and Norway. These multitude routes have been the fruit of deregulation in the Spanish strategy that opened the door for competition in a free market. A steady growth rate in established markets such as Italy, Belgium and France coupled with higher growth rate will enhance the Atlantic Basin market (see Figure 3.6).

In the western part of the Atlantic Basin, Appendix L illustrates the U.S. proliferation of LNG facilities and its very high growth rate despite the shrinking of LNG imports in 2008.

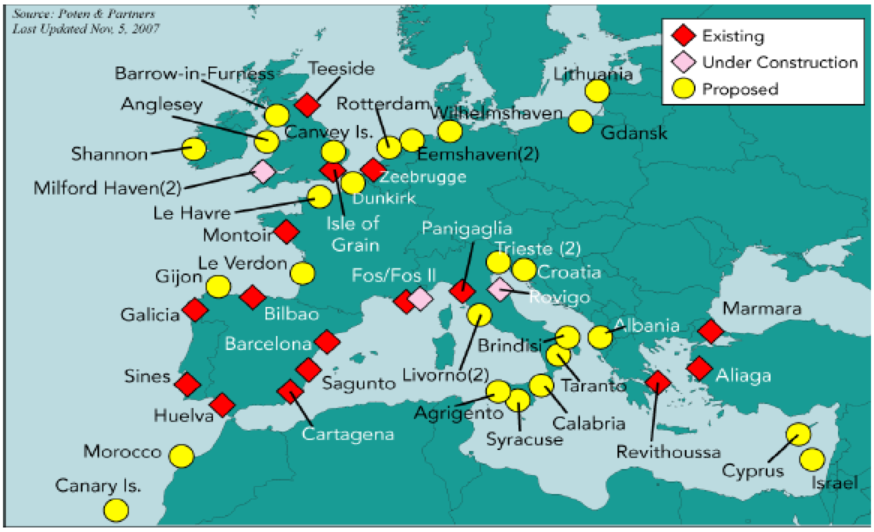


Figure 3.6: European LNG Terminals
Source: Reported Benjamin Schlesinger and Associates by American Gas Foundation from Poten & Partners, Inc 2008.

3.5 Evolution of the Algerian Gas Market.

Among the four main feeders of gas to Europe, Algeria is counted as number four in providing the Continent with gas through pipes. BP announced that in 2008 the Algerian trade movement by pipeline to Europe reached 9% of total pipeline gas exports to Europe, equivalent to 35.75 Bcm compared with 154,41 Bcm, 92,78 Bcm, and 55 Bcm of gas supplies from Russia, Norway and the Netherlands respectively (BP, June 2009). The central role that the Algerian LNG plays in the European market qualifies it to be the first LNG exporter to Europe with 19.38 Bcm (35% of the total LNG European imports) followed by Nigeria with 26%. By both means of transportation, Algeria surpassed the Netherlands in supplying Europe with this energy in 2008 making it the third-largest exporter of gas to Europe despite the two disruptions of LNG deliveries during the year that had reduced the LNG production by 20% (Breidthardt, October 21, 2008).

3.5.1 Proven Reserves

According to Oil and Gas Journal (OGJ), Algeria recorded 159 Tcf of proven gas reserves (the eight-largest in the world) as of January 2009 (EIA, May 2009a). The discovery of the super-giant gas field in 1956 enriched Algeria with 85 Tcf of proven gas reserves which remains up to now the largest gas field contributing a quarter of Algeria's total dry natural gas production. The remainder of Algeria's natural gas reserves center around associated and non-associated fields in the south and southeast regions of the country. In southeastern Algeria, the Rhourde Nouss region holds 13 Tcf of known reserves. Also in southeastern Algeria, near the Libyan border, the In Amenas region includes the Tin Fouye Tabankort (TFT; 5.1 Tcf), Alrar (4.7 Tcf), Ouan Dimeta, and Oued Noumer fields. The In Salah region in southern Algeria holds smaller, less-developed reserves (5-10 Tcf) (EIA, March, 2007).

Since 1990, Sonatrach has followed the joint venture strategy to reinforce the Hydrocarbon E&P and to enrich their resources with their partners. This strategy was successful in helping the gas reserves to reach the 4.52 Tcf in 2000 and to be maintained around this value till 2009. In the following Figure 3.7, the history of the gas reserves shows how effective the collaboration with partners in the gas exploration has been.

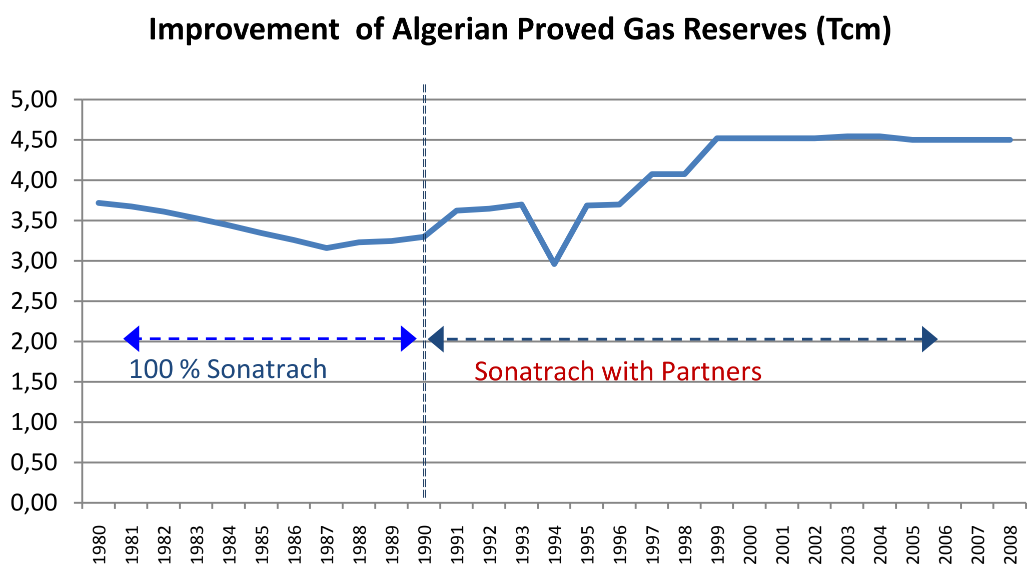
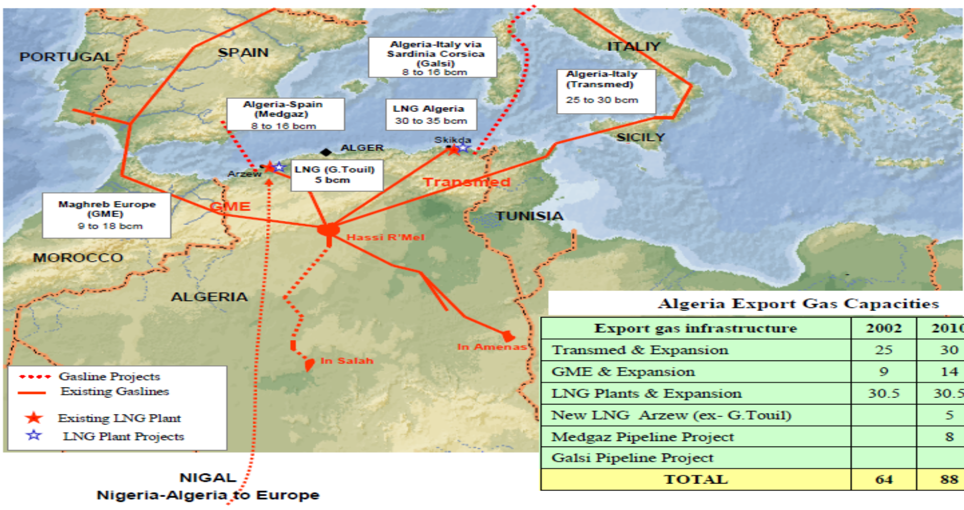


Figure 3.7: Evolution of Algerian Proven Gas Reseves from 1980 to 2009.
Source: Compiled from Data provided in BP Statistical Review 2009.

3.5.2 Algerian Pipeline Network

The Hassi R'Mel natural gas field is the hub of Algeria's entire natural gas transport network. It links both the domestic pipelines and the two pipeline connections to Europe with the 670-mile Trans-Mediterranean line (Enrico Mattei) via Tunisia and Sicily to mainland Italy, and the 1000-mile Maghreb-Europe Gas pipeline (Pedro Duran Farell) via Morocco to Spain and Portugal. Almost two-thirds of Algeria's total natural gas exports currently move through these two natural gas pipeline routes, and the remaining one-third of total natural gas exports is exported in the form of LNG.

The growth in demand from Europe on the one hand and the reduction in costs as a result of the technological development in gas pipeline on the other hand have encouraged other pipeline projects to take place without transiting any foreign countries. The direct line MEDGAZ to Spain and the GALSI to Italy via Sardinia are two projects that will considerably augment the Algerian gas production by 2012 to 85 Bcm according to the Sonatrach (Reuters, May 2009). Figure 3.8 provides a general overview of the Algerian pipeline networks and the estimated growth in gas and LNG deliveries to 2020.



Algeria Export Gas Capacities

Export gas infrastructure	2002	2010	2020
Transmed & Expansion	25	30	30
GME & Expansion	9	14	18
LNG Plants & Expansion	30.5	30.5	35
New LNG Arzew (ex- G.Touil)		5	5
Medgaz Pipeline Project		8	16
Galsi Pipeline Project			16
TOTAL	**64**	**88**	**120**

Figure 3.8 : Algeria's Gas pipeline network and gas export projects.
Source: (Hafner, June 2004). Retrieved from University of Paris (Dauphine).

The Strategic geographic location of Algeria at the crossroads of Africa and the southern part of Europe has also brought the idea to export the Nigerian gas through the country since the prospects of Algerian gas production will not be enough to supply the Continent in the years to come. The prospects of the GDP growth of the European countries combined with the expected increase of the local gas consumption and the reduction of indigenous gas production can affect the EU to import up to 80% of its total consumption by 2030 as predicted by the European Commission (Ericson, July 2008). The Algero-Nigerian 30 Bcm- Trans-Saharan Gas Pipeline project “Nigal”, crossing the territories of Niger, will to some extent relieve the South European countries from the burden of demand by the year of 2015.

3.5.3 Export Terminals

Beside the pipeline network, Hassi R’mel also supports the coastal terminals for LNG exportation. At the end of 2008, BP recorded that 21.87 Bcm of LNG was produced for crossing the seas on board LNG carriers, which represents 36.8 % of the total Algerian traded gas compared with 24.67 Bcm in 2007 that is around the maximum of its total LNG capacity. This difference in LNG production between 2007 and 2008 has principally been affected by the renewal of certain old lines that have started to crack by the age factor.

With the start-up of the Arzew GL4Z Camel plant in 1964, Algeria became the world's first producer of liquefied natural gas (LNG). The success in the previous LNG exportation granted three other LNG terminals to appear namely, GL1K Skikda, GL1Z Bethioua 1and GL2Z Bethioua 2 respectively in 1972, 1978 and 1981 in order to ascertain this experience. Unfortunately, the total capacity of these 4 plants was reduced by the Skikda train explosion in 2004, which shrunk the total capacity by almost 2.5 Bcm (NASFM, 2005).

Table 3.3: Main Current Algerian LNG Terminals.

GL4Z Camel	GL1K Skikda*	GL1Z Bethioua 1	GL2Z Bethioua 2
• Start Up : 1964	• Start Up : 1972	• Start Up : 1978	• Start Up : 1981
• 0.1 Bcf/d	• 0.5 Bcf/d	• 1 Bcf/d	• 1 Bcf/d
• 03 Trains	• 03 Trains	• 06 Trains	• 06 Trains
• Cascade Process	• Teal & Prico Process	• Air Product Process	• Air Product Process
• 03 Tanks (11 000 m^3)	• 05 Tanks (308 000 m^3)	• 03 Tanks (300 000 m^3)	• 03 Tanks (300 000 m^3)

* Reduced Capacity since 2004

Source: Rahal, 2008 (Sonatrach Data).

The rosy prospects in the medium and long run of LNG trading pushed the Algerian government to direct their efforts towards expanding their LNG production capacity in order to meet the international gas demand. With the realization of a new Skikda train and a train being built at Arzew (GL3Z LNG), their total capacity will be 40.2 million tons per year by late 2012.

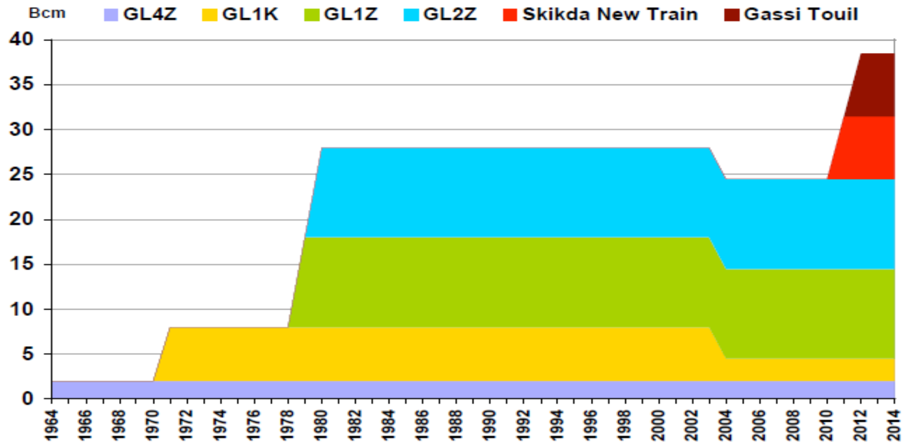


Figure 3.9: Algeria's Liquefaction Capacity.
Source: Rahal, April 2008. Sonatrach Database (Presented in a AFROLAC II conference)

3.6 Algeria Gas Trade Analysis

The country produced 3.03 Tcf of dry natural gas in 2007, and is the sixth-largest natural gas producer in the world. Algeria consumed 0.93 Tcf of dry natural gas in 2007. The remaining natural gas is exported, much of it going to Europe and some to the United States and Asia.

Algeria's dry natural gas exports totaled 2.10 Tcf in 2007, down slightly from 2.17 Tcf in 2006 (EIA, May 2009a). Italy alone takes the lion share of the Algerian gas of 36.2% of the total Algerian gas export, and nearly the same quantity is shared between Spain, France and Portugal. In comparison with Spain that has a pipeline network connected to Algeria's pipeline network by a direct gas pipeline, and Portugal through indirect natural gas transmission network, the inexistence of pipeline links to France renders all the 13.5% of Algerian gas supplies to France to be carried by ships. Algeria also serves other Mediterranean countries such as Turkey, Greece and Slovenia, totaling 12.8% of the total LNG export.

Moreover, the interest of the remote consumers to Algerian gas granted Algeria to penetrate the Pacific Basin market, North European countries and North America. Exports to those regions showed 11% of the total traded LNG recorded in 2008 against 6.5% in 2007. The shortage of Algerian production in 2008 squeezed the U.S. imports that reached 2.11 Bcm in 2007, and the bad luck combined with the slowdown in the American economic development have made the U.S gas supplies of Algeria to be completely dematerialized. For the same reasons, Belgium lost its part of Algerian gas in 2008 and U.K imports from Algeria have been reduced by 42%. In addition, 6.5% of LNG exports were recorded in the Asian market in 2007. (BP, June 2009; Rahal, April 2008).

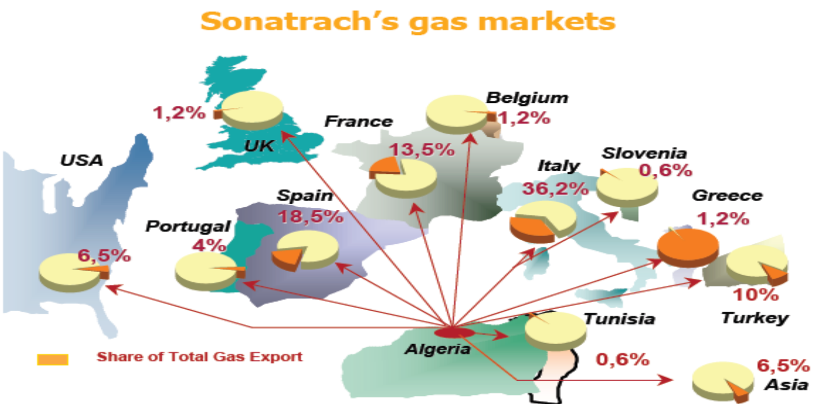


Figure 3.10: Algerian Gas Exports in 2007 (62 BCM).
Source: Rahal, April 2008. Sonatrach Database (Presented in a AFROLAC II conference

By adding the gas sales to Asia, mainly to Japan, South Korea, and Taiwan and recently to India and China, Algeria has brought closer the two adjacent Pacific and Atlantic Basins. The strategic geographical location in the crossroads of these two markets inspires a promising future for the Algerian LNG exportation if the production can meet the expected strong demand in the Asian Pacific market. However, the saturation of gas production on the one hand and the potential big gas reserves such as Qatar to spur the LNG production on the other hand, or any further birth of Russian and Iranian LNG projects to supply the Pacific Basin can considerably limit Algeria's exportation and thus, draw a frontier line between the Atlantic and Pacific markets. At the end, the presence of Algerian gas market in the Asian marketplace will depend much on how these three big countries will develop in the LNG trade to satisfy the region in the long run.

3.7 National LNG Shipping

The Algerian LNG fleet is a state-owned property that is managed by the Hyproc Shipping Co, which is a subsidiary of the national oil company Sonatrach. Five LNG ships are owned totally by Hyproc and three partially with other partners consisting of three joint ventures (JV's). Members of these JV's are Sonatrach, Hyproc, and the Japanese shipping companies Mitsui OSK Lines (MOL) and ITOCHU Corp, which have equal shares of 25% each. The first JV is the Algerian Nipon Gas Corporation Transport (ANGTC) managing the methane Tanker Lalla Fatma N'soumer of 148.000 m^3 that was received in 2004. The second JV is the Mediterranean Liquefied Natural Gas Transport Corporation (MLTC), which is in charge of the 75,000 m^3-Mediterranean Max LNG carrier Cheikh El Mokrani delivered in 2007. The last JV is formed by the Skikda Liquified Natural Gas Transport Corporation (SLTC) where members own parts of the 75,000 m^3 Medmax II Cheikh Bouamama received last year (Hyproc, 2009). In addition to these eight LNG ships, Sonatrach and the Norwegian Bergson (now BW Gas) collaborate in 50/50 co-ownership agreement of the LNG ship Berge-Arzew that has a capacity of 138.000 m^3. After selling the popularly called the "White horse" LNG carrier Hassi R'mal in 2008, nine ships with total capacity of 1,071369 million m^3 are currently managed by Hyproc[1] and time chartered by Sonatrach for a long term contract of 20 years.

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[1] Except for the Berge-Arzew, which is managed by both Hyproc and BW Gas.

Following the cancellation of the construction of Gassi Touil integrated LNG export project under a production-sharing agreement, Sonatrach has pushed the planned reception of two new LNG tankers that were expected to be delivered in 2010 to 2012 and 2013 since the Spanish Consortium Repsol YPF and Gas Natural have failed the contractual agreement with Sonatrach to finalize this project before 2010. Instead, two LNG tankers of 150,000 m^3 are booked to be delivered after Sonatrach had decided to pursue the project on their own (Sonatrach rewrites LNG rule-book, September 2008). This policy allowed the Japanese company JGC Corp. to construct a natural gas processing facility at the integrated Gassi Touil gas project and the joint venture of Snamprogetti and Chiyoda to supply gas as feedstock with 4.7 million tons/year to GL3Z LNG plant at Arzew, which is now under construction with completion set for the end of 2012.

In brief, the development of the Algerian LNG fleet is recapitulated in Figure 3.11 that demonstrates once more the performance of the partnership in developing LNG transportation.

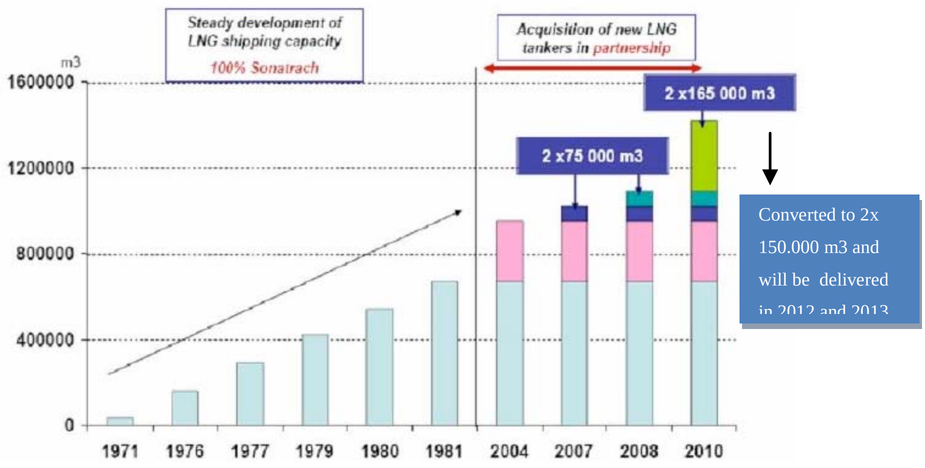

Figure 3.11: The Algerian LNG Fleet Capacity.
Source: Rahal, April 2008. Sonatrach (Presented in a AFROLAC II conference April 2008).

3.8 Algerian Strategy in the Gas and LNG Market

Algeria has currently strengthened its position in the world gas market as a result of the strategy that has been followed during the last two decades. The development in gas resources and the expansion in the gas and LNG infrastructures started when establishing a privileged integrated co-operation and special partnership along all the gas and LNG chain. This is the new spirit of the Algerian energy policy. Partnerships have grown richer and gained in diversity over the past as a result of attracting more gas investments and technology by widespread application of new and more efficient contract-awarding procedures.

To create the mutual benefit with its partners, Sonatrach opens the door to new players. At the same time, it has taken the opportunity to enlarge its portfolio in a new perspective in order to ensure additional sales, secure outlets and capture margins in the value chain by imposing its existence along the whole LNG value chain.

In addition to creating joint ventures in the commercialization of petroleum and chemical products and in the oil and gas infrastructures, Sonatrach has signed many agreements with its partners to operate foreign terminals and take in charge the commercialization of its gas focusing on the U.S and European markets. The joint venture In Salah Gas (ISG) (created in 1997 with BP to market gas to South Europe) and its involvement in the Spanish project Reganosa and in the "Cepsa Gas Commercializadora" (CGC) mark its presence in the commercialization of LNG in the Spanish market and ascertain the supremacy of Algerian gas in the Southern part of Europe. Moreover, joint ventures have been created first, with Gas de France baptizing the Med LNG and Gas joint venture in order to send the Algerian gas to Europe and North America, and second, the leasing of capacity jointly with BP in the Isle of Grain terminal in U. K, in parallel with the leasing of regasification capacity in Montoir de Bretagne. These co-operations indicate clearly the strategy of Algeria to penetrate the distant downstream market to protect and increase its supplies.

Along with the inland gas operation and commercialization, Algeria has been straightforward in the gas sea transportation collaboration as well. The created joint venture with its Japanese partners has given a new spirit to strengthen and expand its co-operations with its partners in the LNG transportation.

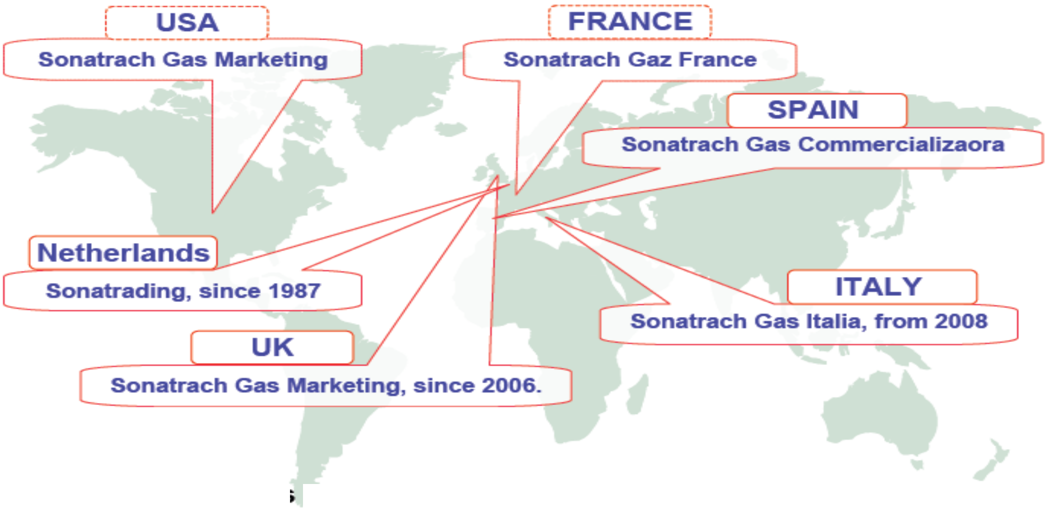

Figure 3.12: Sonatrach's Downstream Positions through Dedicates Affiliates.
Source: Rahal, April 2008. Sonatrach (Presented in AFROLAC II conference, April 2008).

The evolution of the gas environment brings Algeria to develop a dynamic strategy of seeking a better value and diversifying outlets through integration in gas downstream with production sharing contracts (PSCs). This strategy reveals the success in driving its gas explorations and exportation to grow rapidly after a long period of stagnation in the gas investments, and start to realize the importance of the commercialization of this energy in future (Analysis-Liquefied Natural Gas, November 2008).

CHAPTER IV

THE EVOLUTION OF THE LNG SPOT MARKET

An Analytical Comparison to Oil Market

4.1 Introduction

The LNG market is showing signs of a mutation from a traditional enclosed market to an open market, designed to facilitate LNG trade in the changing gas industry. In the LNG market today, as in the oil market prior to the 1980s, closed-loop projects are the standard. Firms search for trading partners and sign long-term contracts before investing in production or end-user infrastructure. When driven by concerns about security of supply and portfolio diversification, the need for flexibility in transactions and fluidity in LNG itineraries has persuaded both sellers and buyers to shorten contracts and to change the incumbent obligations in the binding agreements into freer versatile ones.

An analysis of the dimension to which the LNG spot market is expanding in comparison with the oil market has its merits as many similarities evoke an identical development. The structural changes seen recently in the gas industry have enhanced this parallelism, but some constraints in the inherent structure of the LNG value chain are hampering its evolvement to follow the pattern recognized in the oil market. So, it is fundamental to properly comprehend the extent to which the LNG spot market will develop in the future to draw a comparison between the two markets. This will be achieved in the following after examining the current metamorphosis in the structure of the gas market.

4.2 The Evolving LNG Spot Market

4.2.1 Definition and Misconception

Before elaborating the evolution of the LNG spot market, it is quite important to clear some misinterpretations that may lead to confusion. The meaning of a LNG spot trade has always been an issue for authors to define as it overlaps with short and mid-term trade definitions and some other type of transactions. For a better understanding, a close look at the different types of contracts in the LNG sale and purchase is needed first.

According to the LNG glossary published by Petroleum Economist, three types of LNG contracts are categorized as follows (Petroleum Economist, November 2006):

1- *Long term contracts:* a supply contract in the physical market covering natural gas deliveries for more than 20 years.

2- *Mid-term contracts:* a supply contract in the physical market covering gas deliveries up to 18 months.

3- *Short-term contracts:* natural gas purchases usually involving 30-day, short-term contracts or spot gas.

Though the definition of the spot market appears to be more precise, which refers to "a *market in which natural gas is bought and sold for immediate or very near-term delivery, usually for a period of 30 days or less*" (EIA, October 1999), specialized agencies and oil and gas companies, such as EIA and BP, broaden this definition to include in the spot market volumes traded in mid-term contracts (as defined by Petroleum Economist)[2] (Hull, 2007; Pirog, 2004). Moreover, volumes traded in swaps and diversion are counted as if they pertain to the spot market despite their nature of being part of the long-term contracts. Thus, since a genuine LNG spot market does not exist in its proper sense, this paper will review the spot/short term trade by its broad meaning referring to various data provided from different sources.

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[2] British Petroleum considers spot/short term contracts up to 2 years whereas EIA assumes in its statistics the allocated volumes in the spot market.

4.2.2 Development of the LNG spot Market

The first appearance of the spot market occurred accidently in the 1990s when over eight million tons of LNG oversupplied the market due to large de-bottlenecking projects increasing the capacity in South East Asia and timing the LNG expansions in Indonesia and Malaysia. This accidental surplus capacity endured throughout the 1990s as a result of the financial crisis in 1997-98 that reduced demand in Asia and due to the new entrance of Qatar as a significant element in the LNG spot market. It was only in 1999 that surplus capacity was built on design, to take advantage of the more flexible market emerging (Jensen, 2004).

Today, EIA notes that the LNG spot market is "small but growing rapidly", and concomitantly seeing a structural change (EIA, 2003). The combination of high gas prices and low LNG costs has contributed to encourage suppliers to monetize their available reserves. As a result, the increased volumes from the Middle East are now playing a balancing role in directing the cargo to the market with the highest profit contributing to link the inter-regional markets and to enhance the LNG open trade.

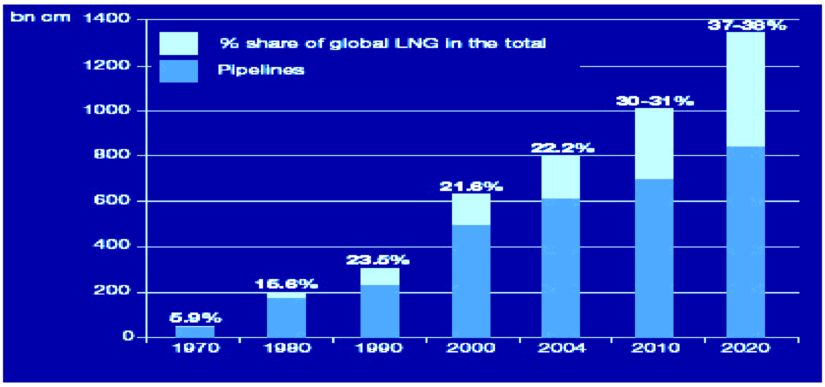

Figure 4.1: Global LNG Growth.

Source: PriceWaterHouseCoopers, 2007. The Value and Growth in the Liquefied Natural Gas Market

There is no doubt that the growth of LNG trading is overtaking pipeline gas development (see Figure 4.1) due to the growth of LNG demand on one hand and the absence of indigenous or neighboring reserves of the major gas consumers on the other hand, depriving as such, for instance Japan, south Korea and Taiwan, the opportunity to be fed by foreign pipeline gas. Nonetheless, this presumption does not stand alone in justifying the inclination of some buyers to LNG since the advantageous character of LNG transportation to be more flexible than gas pipelines is attracting more gas traders to satisfy their needs for diversification and security of supply.

Hence, the development of selling LNG without commitment to regulate the LNG demand/supply balance has grown impressively increasing within a short period from zero before 1990 to reach 13 % of the total traded LNG at present. According to Poten & Partners, the moving towards larger spot market will increase spot volumes to 20% of total LNG traded shares in 2012 (LNG Spot Trading to Capture 20% of Market by 2012, Poten Says, July 21, 2008). Figure 4.2 showcases the past evolution of short-term contracts from 1994 to 2009[3].

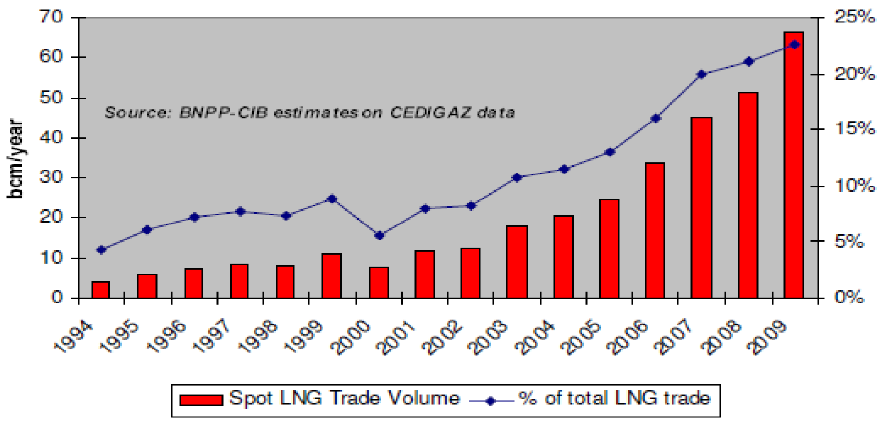

Figure 4.2 : Evolution of LNG short-trading contracts.
Source: (BNP Paribas, January 2009). BNPP-CIB estimates on CEDIGAZ data.

4.3 The Changes in LNG Market Mechanisms and Contracts

The LNG market has usually been perceived as a "rigid" structure due to the complexity and high costs associated with setting up the value chain. Long-term contracts and vertical integration have been accommodated to the industrial environment in which few players were involved in the LNG trade and stiff

[3] CEDIGAZ data includes short-term contracts of 3 years or less which renders the definition of the spot market more complex.

regulations hindered the distortion of the LNG chain. Accordingly, LNG vessels have been operated on fixed contracts, owned partly or fully by the oil companies; liquefaction plants were constructed in cooperation with construction companies and host governments; and the reception terminals were owned and operated by a buyer such as a power producer (Palm, 2007).

In traditional long-term LNG contracts, buyers and sellers are committed to fulfill all the obligations containing “take or pay” (ToP) clauses that meant that the buyer is obligated to take delivery of the contracted volume of LNG whether he needs it or not and to pay if he does not. In a period of 20 years or more, a standard period to secure return on equity, to make sufficient netbacks for the investment, and to reduce risks of supply, buyers and sellers fuse their interests into one investment. As a consequence, the success of this investment is tied up to the completion and functioning of all the elements in the value chain and the coordination of all participants involved in the project is crucial for achieving the planned objectives. Any delay in one process of the value chain, for instance in the completion of a reception facility, will frustrate the entire project and will generate substantial losses.

The integration of such formidable investment in an LNG project offers certain advantages for both traders such us ensuring a parallel growth, continual availability of product for buyers, and income stability for suppliers (Juris, 1998; Alavi, 2004). However, the nature of contracts that bind the parties for a long-term bilateral contract generates some rigidity in trade and management. Despite, the introduction of some flexible clauses in the Sale and Purchase Agreements (SPA) to abate the volume risks with a Downward Quantity Tolerance clause (DQT) and Profit Sharing Mechanism (PSM), it is still not sufficient for certain consumers who call for other suppler forms of contracts. As an advantageous alternative for sellers, the Price Escalation Clauses (PEC) or Price Review Clauses (PRC) are often incorporated in these types of contracts to face the price uncertainties, but the desire for making more interesting profit in the spot market appeal their appetite to prefer short-term contracts or spot sales.

In recent years, short-term contracts have appeared to supplement the long-term contracts in order to fulfill the contemporary technical, logistical and commercial requirements. Giving the fact that, as discussed earlier, technological advances have reduced the capital expenditure and allowed the growth of LNG infrastructures the disintegration of the LNG value chain is today a strategic tendency that aims to control gas volumes and to avoid risks and uncertainties. A sign of this dislocation from the whole LNG project is that more regasification terminals are being built independently and more LNG ships are being ordered without any commitment to a project.

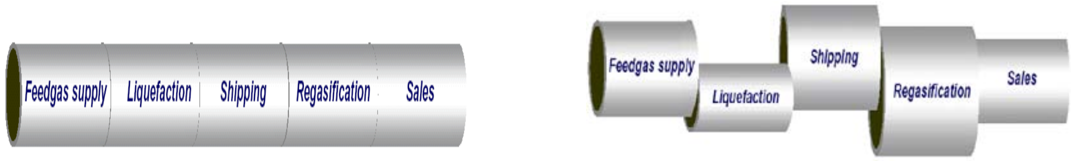

Figure 4.3 : Unbundling of the LNG value chain
Source: Alavi, 2004.

European Union Commission admits that long-term contracts are gradually seeing opposition from certain buyers who look for diversification of markets (EU Commission, 2003). However, Cogan J.r (2006) affirms in his article published by the LNG Observer Journal that the trend of the LNG SPA will continue to exist as the LNG market evolves (Cogan Jr, 2006). The same conclusion is reached by James T.Jensen (2003) when he said that the SPA will persist lastingly in parallel with the growing spot market. So, the question remains whether some producers will choose to sell on a short-term basis or to renew the expired contracts in future.

4.4 The Changeover of Pricing Mechanism

4.4.1 Pricing System

In general, traders buy and sell gas on hubs, either on the spot market or forward/futures market. The spot prices are determined by the current balance of supply and demand in a market where there is a settlement to deliver the gas to the respective parties in the next one or two business days. In the forward/futures[4] contract, price is determined by the expectations of what demand and supply will be in the future, along with a risk premium, and it is paid today to be delivered at a future date.

Natural gas prices are linked to the oil price because they are considered to be intersubstitutable and competing fuels. In the long run, gas prices are more stable than the oil price, but factors such us weather, seasonality, storage and disruption of production usually create differences between oil and gas values making the gas price instable in the short run (Brown & Yucel, 2007).

As a rule, LNG prices are linked to those of crude oil, but in fact, they follow a range of formulas in three marketplaces on stream. Each market is separate and fairly autonomous for LNG, located namely in the US, Europe, and Asia. Each of these three markets has a structure that is exposed to its own uncertainties influencing the fixture of the LNG price. For a contract in the US, which is the main spot market in the Atlantic basin, the competing fuel is pipeline gas. The price in the contract is specified according to the contracted price or to the Henry Hub price for short term sales. The gas price in this market is very instable due to the volatility of the US gas market.

In Europe, the competing fuel is low-sulphur residual fuel oil following the natural gas spot and futures market prices on the ‘virtual’ National Balancing Point (NBP) hub in the UK and Zeebrugge. The price in Europe seems to follow that of the US as the gas-to-gas competition policy has started to affect gas prices. In Asia, even though prices lack some transparency with little progress in relation to gas market liberalization in the region, they are still benchmarked to imported crude oil. The price formula involves a base price to contracts in Japan indexed to the Japanese

[4] Specific to Henri Hub index on NYMEX.

Crude Cocktail (JCC). As in recent years, the region has seen high demand for gas, Asian prices are inclined to be higher than what usually obtains (see Figure 4.4).

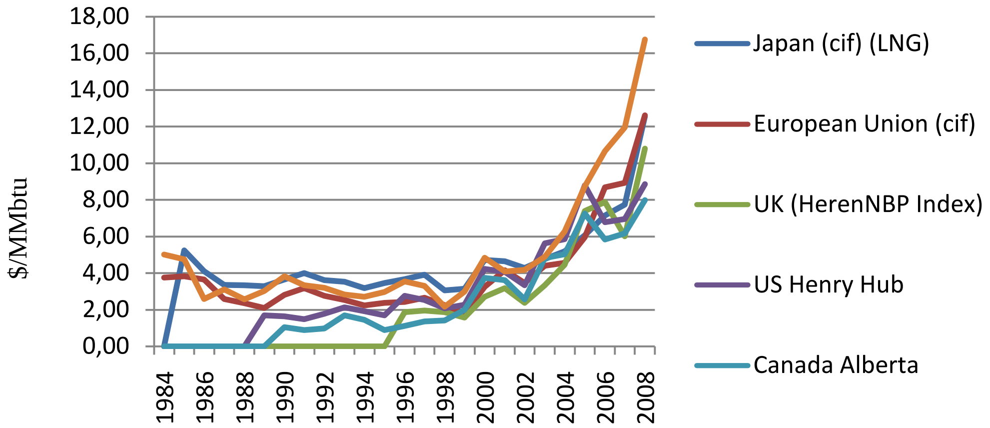

Figure 4.4 : LNG prices in differential in the three regional market
Source: Compiled from BP Statistical Review Data 2009**.**

4.4.2 Arbitrage and Migration of LNG Spot Volumes

The gas price in a market is determined, as explained above, by reference to the local hub. However, any distance between a remote submarket and its reference hub may increase or decrease the transportation costs according to the distance differential between the upstream-downstream and upstream-hub. While this issue is resolved by adjusting price by the means of the so-called" basis differential" that measures the geographic dispersion of LNG contracts from the reference hub, no price adjustment formula exists between markets that belong to different hubs since they react independently. Hence, the price imbalance between different markets, once adjusted to their local hubs, is that what creates "arbitrage".

According to the theory, "*arbitraging possibilities occur in cases when the price differential of a homogeneous commodity exceeds transportation costs*" (Neumann, 2007*)*. This phenomenon was first noticed in the Atlantic Basin when financial gain occurred from directing LNG volumes from Trinidad and Nigeria to the United States or alternatively to Europe (primarily to Spain). Then, another pattern of arbitrage has developed between Northeast Asian markets and Atlantic Basin markets via shipments from the Middle East where Qatar was in a position to ship either to Asia or to the Atlantic Basin according to the highest netback signals (Jensen, 2004).While today the regional markets are still operating independently, many opportunities occur when any of these markets is disrupted to give the advantage to the other markets to absorb the available spare volumes in the strong market.

The stream of LNG volumes changes its direction to a market where the marginal benefit is comparatively higher. This concept was applied in 2008 when delay in global liquefaction projects and plant shutdowns, combined with sharp increases in Asian and European demand occurred, causing US imports to plummet (the LNG volumes) and to revert the pendulum to Asia (Gray, February 2, 2009b). But today, the LNG market in the US, the market of the last resort, starts to breathe with the turmoil that still persists in the other OECD countries (Oil and gas seesaw, July 2009). At present, as it was expected by experts at the start of this year, the pendulum is moving again to the US when prices in the other markets decrease and the US economy is showing relative refreshment and inclination to energy consumption (Wingrove, Jan 7, 2009; Oil and gas seesaw, July 2009).

4.4.3 The Convergence towards a Global LNG Reference Price

During the conference held in Berlin last year, the Global Public Policy Institute (GPPI) affirmed that the current trade of the natural gas market is not a truly global market at the present, but indices show that it is changing progressively (GPPI, September 2008). The difficulty and cost of transport makes natural gas operate within a series of isolated regional markets with little or no communication among the Atlantic Basin (including Europe) and the Asia-Pacific region. However, many signs in the gas trade evoke the future integration of the gas markets into one world gas trade circle.

The interconnection of the Pacific with the Atlantic Basin has become feasible with the reduction in transportation costs coupled with the creation of one supply-side link. Qatar has become the global leader in LNG production making volumes swing either way. In addition, the emerging countries, such as Oman and Egypt, have started supplying farther markets in both regions by joining this link. Also, with the Algerian, Nigerian and Trinidad LNG cargoes to Asian countries and the probable reverse routes from Austarlia and Malysia to the Atlantic Basin, the price relationships in what is now an increasingly global LNG market may become stronger in the mid-term.

In addition, a premonition tells that the European and the US gas markets are converging towards a unified market and to one reference price resulting from the gas-to-gas competition policy which may decouple the gas price from the oil price. In Asia, the de-linking has occurred systematically when the oil price surpassed 50$/barrel in 2005 and remained lastingly high. However, the gas price is protected by the "S-curve" formula[5]. So, given the recent volatility in the oil market, many consumers are choosing to break the connection between natural gas and oil prices hoping that the price of natural gas will be based on market fundamentals, which tend to keep prices low. In contrast, a hope of selling gas at a higher price makes the main suppliers to Europe such as Russia, Algeria, and Norway, unsatisfied about the outcome of this policy, and have argued that the "S-curve" arrangements were designed for "temporary" oil price volatility and high oil prices were the new norm (ECS, 2009).

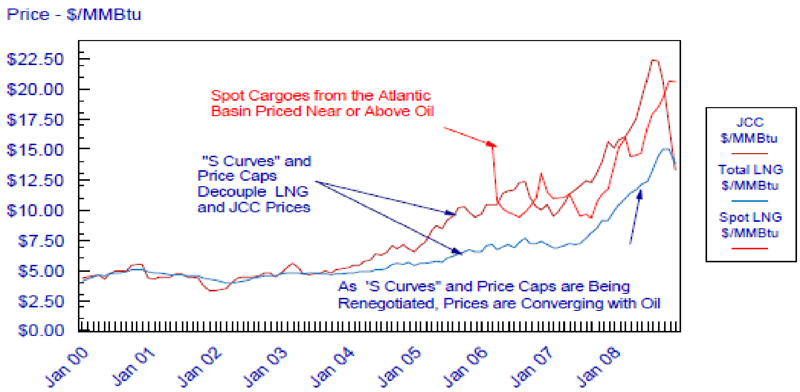

Figure 4.5: Decoupling of Japanese LNG and Crude Oil Prices through S Curves.
Source: ECS, 2009 reported from from Jenson Associates.

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[5] A formula that reduces volatility in gas price and gives a certain stability to protect buyers and sellers , sometimes limited by caps and floors.

Another indicator of a desire for a more actively traded market is that some buyers in Japan want to switch part or all of the indexation of their long-term LNG purchase contracts from the JCC to the Henry Hub index, which, unlike the JCC, has an actively traded futures market on NYMEX that enables buyers to manage their price-risk exposures through hedging (Petroleum Economist, 2007).

The destiny of the spot market and the LNG prices will depend on the willingness of some countries to invest in the LNG storage hub as well. The plan is to set up an LNG storage hub in Dubai, a bid to become the LNG trading capital, which will act as an intermediary between buyers and sellers. The hub would enable both parties to take advantage of price and demand volatility, which in turn would help the spot market to expand and to stimulate the creation of futures market or other derivative instruments for LNG and LNG shipping (Petroleum Economist, 2007).

In contrast, some experts are less optimistic about the globalization and the unification of LNG prices in the near future. Ian Lawrie, a marketing manager for Statoil Natural Gas LLC, expresses his predictions regarding the development of the LNG spot market by saying “I think there's contractual and structural rigidity that makes it difficult, at least in the medium term" (Nichols, June 2007). Another analyst, Lorio, also affirms that "These are different markets," he said, "Correlation will remain low" (Nichols, June 2007).

Different opinions pop up in this sense to pinpoint the drivers pushing towards the development of a global gas market and the unification of LNG prices, but some constraints still prevail in speeding up its mechanism. That is why Igor Shuvalov, a Russian First Deputy Prime Minister, refutes the idea that a single LNG market exists today, but predicts its naissance in a few decades (Pose, 2007).

4.5 The Changes in LNG Tanker operations

The growth of LNG shipping is fast and efficient. It has undergone a deep transformation, not only in the technological and economic improvements (scale-up, new way of looking at LNG transportation, and cost reduction), but also in the commercial strategy of concluding contracts following systematically the development of an LNG spot market. So, the need of a balance between uncommitted LNG volumes and transportation makes the evolution of LNG spot market very sensitive to the availability of LNG tankers.

According to Drewry (2009), the LNG fleet has exceeded 300 vessels (316 vessels) as of June 2009 and it will increase by 23.5% by 2012 comprising 29 ships that are waiting for delivery at the end of this year (Drewry, July 2009). Only half of the fleet that will be available in 2009 existed in 2004. This impressive growth of LNG tanker capacity within only 5 years has broken the record in the sector where it has never seen such an upsurge in the past and probably will never witness a growth of 20 % per year seen in 2008. BRS (2009) expects that around 52 million cbm of LNG capacity will be reached in 2012, compared with 49 million cbm estimated by Drewry, thanks to the scale-up of vessels and the new Qatari projects, and another 30 million cbm will be added until 2020 to form a tanker fleet with 540 vessels (BRS, 2009, Drewry, July 2009) . Figure 4.6 illustrates the trend of LNG shipping growth and the average LNG capacity added each year with the number of LNG carriers.

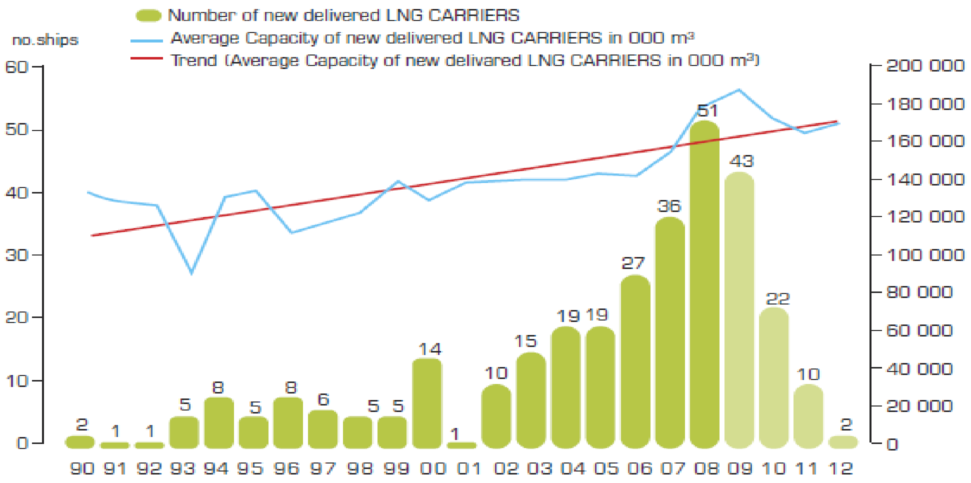

Figure: 4.6: LNG vessels Delivery and Trend.
Source: BRS, Annual Review 2009.

The traditional practices in contracts relative to LNG tankers were limited to specific trades. In most of the cases, new supply contracts required newly built tankers destined to operate in an inflexible market, which meant that there was no possibility to charter a ship if it was idle for any problem occurring in the flow of the contracted LNG cargoes. This lack of contractual flexibility deprived a ship the opportunity to cover cross trading and to minimize its transport costs, especially with the continual development of dispersed LNG infrastructures. Furthermore, once long-term contracts expired, LNG ships were sent to scrapping, converted to other facilities or maintained to operate inefficiently in the spot market due to limited effective life[6]. In long-term contracts, new vessels are preferred since renewing contract extension for these unreliable old vessels may not permit to outlast their employment efficiently for another long period than the period they were designed in purpose.

However, with the growth in the LNG tanker world fleet during the last decade and the introduction of longer useful life of new LNG ships that may attend the LNG market for 40 years, the new perception in LNG trade has transformed the long-term contracts in LNG tankers to take another dimension by allowing them to perform in short-term contracts and spot sales. The benefit from arbitrage has even encouraged some LNG majors to speculate on newbuildings aiming to employ the delivered LNG tankers in the spot market. Consequently, as stated by Dorigoni, Mazzei, Pontoni and Sileo (2008) and Jensen (2004) in their analysis, and also other analysts interviewed by Tradewinds Journal, this trend in LNG shipping has already triggered a market for "second-hand tankers" and it will evolve in harmony with the evolution of the LNG spot market in the long run (Dorigoni et al, 2008; Jensen, 2004; Hine, March 2008). In contrast, one expert reported that there is no incentive to buy old vessels when the market is weak and others foresee the birth of a second-hand market only with regard to the generated overage LNG carriers that are likely to be transformed into FSRU/LNGRV (Floating Storage and Regasification Unit/LNG Regasification Vessels) (Hine, March 2008).

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[6] The maintenance of old LNG ships which outreached their effective life may generate very high costs.

The effect of the LNG market on LNG tankers has also created different conceptions of LNG routes resulting from softening long-term contracts. The needs for flexible contracts have pushed some agreements to curtail destination restrictions to allow each tanker to route multiple destinations and LNG buyers to divert their own surplus on a short-term market. Some LNG majors have integrated downstream through self-contracting with their marketing affiliates promoting LNG tankers to shuttle between different destinations. According to Dorigoni et al (2008) these arrangements may not fit either the traditional definition of “dedicated” trade nor can it be classified as “speculative.

4.6 Changes in Regulations

The changed regulatory policies seen over the past have favored many non-utility generators to emerge in the gas and power industry around the world after the deregulation seen in the gas industry of the two major markets, the US and UK. With the progressive spread of this policy into European and Asian markets, it has enhanced the spot trading to grow fast giving opportunities to new players who are willing to take the risk and participate in the LNG market in a big way not only as buyer but also as traders.

The change in regulations driven by the environmental concerns is another aspect that is progressively influencing the way of thinking about energy choice towards gas. Pressures from international and national communities on the energy consuming countries start to change the strategy of certain consumers to shift from polluting fuels, such as coal, to other environmentally friendly energy sources. For instance China, by the ratification of the United Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol on the one hand, and the government policy to cut energy consumption by 20% in five years on the other hand have caused many LNG reception facilities to come into existence and many are projected to come in the mid and long term whereas the primary energy in China is still dominated by cheap coal (Guangchuan, 2009). So, the growth of the LNG market as a result of the environmental regulations can considerably influence the demand of gas and can spontaneously reinforce the LNG trade in the open market.

4.7 Analogy between LNG and Crude Oil Development

The increased LNG infrastructure in the downstream has promoted the emergence of a spot LNG market, which is expected to grow rapidly in the future. This development is similar to that which has emerged in the market for oil over the last three decades. Given the apparent similarities between the development of oil and gas markets, the question arises as to whether the structure of the gas market will evolve towards that prevailing in the market for crude oil.

4.7.1 Structural Development

Some structural specificity in the industry of gas may be considered among the influencing factors that may create a favorable environment to model the LNG market according to the oil market. Similar to oil, gas resources are highly concentrated and increasingly controlled by state-owned enterprises involving the same major powers in oil to play in the gas industry. The wave of mergers and acquisitions that have been seen in the oil sector is also seen in gas trade by vertically integrating buyers and sellers seeking for a stronger position in the market. In both fuels, the transportation is politicized by the need for transit routes both through transit countries (pipelines) as well as safe routes through certain shipping passages in the world.

4.7.2 Conceptual Development

Similarities in conceptual framework development between oil and gas are drivers to assimilate their trends. The oil sector started with point-to-point contracts and was strongly influenced by the major international oil companies up to the 1970s. Since then, it has been fully commoditized through the development of spot and futures markets after the introduction of netback pricing in the mid-1980s (taken over by OPEC) since when, arguably, the market has governed prices. The same pattern is seen today in the evolution of the LNG industry, when calling for energy security is favoring this resemblance.

For example, in the oil market, calling for diversification, to avoid political risks, to control volumes, and to minimize costs disruption and dependency on the traditional suppliers have been incentives for many oil companies to look for available fuel quantities in the spot market and to plan for strategic stocks as insurance. This propensity is accentuated in the gas sector, firstly with the more recent slowdown of the market, which has created a surplus of LNG finding its way onto the markets through short-term and spot transactions economies, and secondly with the emergence of technical and political risks that gas producing and consuming countries have witnessed lately.

4.7.3 Shipping Development

In shipping, the change in management strategy of certain shipping ventures can lead to the assumption that the LNG shipping is imitating the same structural configuration of the oil shipping market that began to transit three decades ago. The rapid growth in LNG demand and supply has engendered a parallel increase in spare volumes within a short period giving a systematic development of LNG tankers to operate in the spot market.

The resemblance of oil shipping with LNG shipping can be seen from two perspectives. First, oil companies are gradually involving third parties to play in LNG transportation as the freight rates become rather unattractive, aiming to reduce costs and to benefit from competition in transportation (Jensen, 2003). As a consequence, speculative LNG ships are being built today in shipyards without being dedicated to any project. What is more, a considerable number of long-term contracts are expiring, spawning as such a new group of uncommitted LNG tankers to operate in a new LNG spot environment. This is the result of the difficulty to renew them in long-term contract extensions as they become aged, combined with the need to add more capacities to the growing LNG spot market.

From the second perspective, the scenarios in the second-hand market and scrapping, as recognized in the evolution of oil shipping, have started to appear in the LNG market. Simultaneously with the proliferation of LNG tankers, LNG ships become more and more aged and the need for replacing them will certainly create a scrapping market and even speculative sale and purchase markets that are practically non-existent today in the infant spot market (Hopkins, 2008). This suggests that the LNG tanker business will increasingly look like the oil tanker business.

4.7.4 Pricing System Development

The pricing mechanism in the gas market is another aspect to identify similarities between the oil and gas markets. The change from fixing gas prices with diverse oil-linked methods into one global reference pricing system that complies with the law of demand and supply is underway. In the oil market, prices now fluctuate freely in response to demand, spare production capacity, refining capacity and supply security. In the gas market, netback pricing is already a reality in gas with the growth of the spot market, the emergence of global gas-to-gas competition and the definite possibility of a futures market.

Moreover, another similarity to oil is well noticed in the control of gas price volatility. Speculation over the possible formation of a "gas OPEC" is on the rise. The meeting of some major powers signals the start of a cartel that makes some consuming countries especially in Europe worried about its consequences. Even though the establishment of the Gas Exporting Countries Forum (GECF) in 2001 aims to generate a ``tangible cooperation among gas producing and exporting countries in gas industry`` (EIA, May 2009), the performance of such a cooperation has not yet been perceived as a threat to competition. However, the invocation of the idea to create a cartel with a more active group and with the same functionalities as that of OPEC inspires attentiveness of some more powerful producing countries to go further than GECF. Published in the Guardian Journal, Terry Macalister announced that a cartel which will control 60% of the world`s gas supplies, has already been created by Russia, Iran and Qatar (Macalister, October 22, 2008). With this step, the rapprochement between the functions of gas-OPEC and oil-OPEC may anticipate the traded LNG to follow the oil trading pattern, but due to certain inherent hindrances in the LNG market structure that may constitute a serious obstacle to trading LNG with the same characteristics as the oil market.

4.8 Constraints in the LNG Spot Market Compared with Oil Market

The common denominators between the gas and oil markets give the impression that the first market is cloned from the second, and their trends are exactly alike. However, opposing forces to the development of an LNG spot market seem to falsify this theory due to some constraints stemming from the physical inflexibility of the gas market. For this reason, the majority of experts do not view that the gas and oil markets as identical. Jensen (2004) stated clearly that `` The LNG market is not; nor will it ever be, as flexible as the world oil market ``and attributes the causes to its special processing and handling requirements make the costs of moving natural gas significantly higher than the costs of moving oil (Jensen, 2004). GPPI (2008) consider it to be `` unrealistic to expect that such a global gas market would resemble that of oil`` by adding that ``gas prices have a larger effect than oil on consumers`` since gas represents the primary method of heating in homes and businesses (GPPI, September 2008).

4.8.1 Project Costs

From exploration to consumption, natural gas goes through different processes to reach the final user and, compared with oil, a gas project needs additional infrastructures to convey it globally. The huge end-front investment involves 58% of the capital expenditure in the host country; 10% are located in the consuming country and the remaining 32% are required for the tankers. LNG transportation costs some 6 to 7 times more than oil transportation, and the cryogenic tankers are much more costly than oil tankers because of the low density of the product and the need for insulation and low temperature metallurgical designs (Swartenbroekx, November 2007). This makes the cost for a standard size LNG tanker twice as high as that of a VLCC (see Table 4.1).

Table 4.1: Comparison between Oil and LNG costs in 2003.[7]

	LNG		Oil	
	CAPEX	**Cost of Service**	**CAPEX**	**Cost of Service**
Field Development	$1.3Bn	$0.8 $/MMbtu	$1.3Bn	17.23 $/barrel[8]
Liquefaction	$1.6Bn	1.22$/MMbtu	-	-
Tankers(10 @ $160 Mn)	$1.6Bn	0.98$/MMbtu	$0.8Bn (VLCC)	2.0$/barrel
Regasification	$0.5Bn	0.39$/MMbtu	-	-
Total Cost[9]	$5Bn	3.39$/MMbtu	$2.1Bn	19.23 $/barrel or 3.4 $/MMbtu [10]

Source: Jensen, 2004; RPT-Oil field development costs up 50 pct 2003-06 –EIA. (2008, January 11). Reuters.

The limitation in storage of LNG is another parameter that has a substantial effect on obstructing LNG to develop in the spot market. Managing LNG stocks will provide a tendency of producing countries to operate in the spot market and to have the ability to control price volatility, as is the case for OPEC, which usually puts oil in a bucket and keeps it there until prices rise. In LNG, however, the storing infrastructure is not only expensive to construct, but also generates maintenance costs when keeping gas in liquid form. In the downstream, the storage tanks in a terminal are the most expensive items accounting for one-third to one-half of the entire cost, depending on the kind of tank[11]. Thus, LNG is far from reaching the flexibility that oil provides in storage.

Unbundling the LNG value chain into separate investments has consequently split

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[7] Two LNG trains of 3.3 Million metric tons. Distance 6,200 NM (Roughly Nigeria to the US Gulf).
[8] The cost of oil production varies according to many factors including the depth of wellheads. This has been reduced by 50% in 2006.
[9] In 2003, total costs of oil and gas were same. The same remark is noticed in the price of oil and gas when gas price varied between $5 to $6/MMbtu, and oil between $28 to $34/barrel. Today, the price link between oil and gas has been broken due to the high oil price (no price/energy content link).
[10] The conversion from a barrel of oil to MMbtu depends on the quality of the oil. We assume that 5.66 barrel of oil contains 1 MMbtu.
[11] It depends on whether it is stored in salt cavities, depleted fields or aquifers.

the risk sharing logic that was embodied in the phrase “the buyer takes the volume risk and the seller takes the price risk” and which was secured under the umbrella of bilateral agreements between government monopolies or franchised utilities and national companies or international oil majors. Liberalization in the gas industry, however, has given rise to smaller buyers that cannot bear the huge volumes in a contract of a Sale and Purchase Agreement with the ``take-or-pay`` clause, and thus, have started to assume their own project risks in the downstream. In addition, sellers who intend to create LNG spot volumes have to ensure in advance that available tankers are ready for the purpose. This may give reason to resort to delivered ex-ship or CIF contracts including the transportation costs so that suppliers can assure the LNG carriage before any new investment or decision-making in the spot market[12].

As a result, the repercussions of the above factors give birth to migration of investment risks in the upstream, which may encumber financial creditworthiness. As the upstream facilities are capital-intensive with delayed payback, investing in an uncertain market may give fewer incentives for suppliers to invest in their own facilities which, in consequence, can draw deterrence in the LNG development by stemming the supply side. Given the huge investments inherent in the LNG value chain, the capital-intensive upstream remains the only obstacle that entices to call for long-term contracts to secure demand and thereby hampers spot trading.

4.8.2 Technical Problems

The difficulty of an LNG project to smoothly respond to volatile short-term price signals makes the difference between the oil and LNG markets. The simplest LNG project is usually conceived in 3- 5 years, consequently, the long lead time and other technical emerging uncertainties may create risks in the development of the LNG market, which can cripple the completion of the project.

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[12] Traditionally, long-term contracts have been priced ex-ship or CIF, but buyers are increasingly calling for FOB contracts to control the resale of excess cargoes and to acquire a greater flexibility regarding shipping costs and the ability to exploit profit opportunities through arbitrage.

In the absence of timely investments, problems associated with 'supply bottlenecks' could emerge and may persist due to the physical inflexibility of the LNG supply infrastructure. Recently, the gas industry has recorded many LNG project delays and cancellations. Accordingly, shipping has been hit by the inappropriate scheduling that has left LNG tankers without employment. In the oil market, idle ships are usually the result of the natural disequilibrium of market fundamentals and price fluctuations while delay in LNG projects remain the crucial cause that may create disequilibrium between demand and supply and thereby a surplus of tankers. Also, the high exposure of LNG infrastructures to technical problems compared with that of oil is another important parameter that may cause unexploited other LNG fleet capacity. This was the case in the Algerian LNG supplies when they were reduced considerably first, by the explosion of a liquefaction plant in 2004 in the Skikda incident, and second, by the two break-downs of old pipelines in 2008.

As seen above, LNG development will remain slower and more exposed to technical problems than in the oil market, and in the expected circumstances[13] since demand is growing faster, demand will outstrip supply in the long run, which may create competition between buyers to acquire this fuel transported by sea.

4.8.3 The need for Long-term planning

In contrast with security of supply that requires buyers to diversify their gas imports so as to avoid the geopolitical impediments and their dependency on one supplier, the rapid surge in gas demand compared with tight supply seems to reverse this strategy as competition will restrain availability of gas volumes.

Unlike oil, which is primarily used in the transportation sector, gas is mainly used for stationary purposes at a fixed site, such as space heating in residential and commercial buildings. As these sectors are very sensitive to gas consumption and gas

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[13] Today, the financial crisis has reduced worldwide gas demand significantly and consequently, a surplus in gas supplies has emerged. The economic uncertainties are sometimes factors that reverse the long –term expectations.

interchangeability is lower compared with oil, the desire to look for more stability in supply is a prerequisite. For example, the announcement of Algeria to shorten their contracts has not been welcomed by Europeans who are more keen on stability than on diversification. The immense project that seeks to construct a long gas pipeline from Nigeria to Europe also demonstrates this strategy.

Beside Europe, and apart from the US, which is heavily involved in short term contracts as only 3% of LNG is now required to complement their needs, those who rely entirely on LNG, such as Japan and Korea cannot bet all their supplies, only on the uncertain spot market; long-term contracts are necessary to ensure stability in gas supplies especially in case of force majeure[14].

4.8.4 Tanker Development Restrictions

The unavailability of LNG tankers is a major obstacle for growth of an LNG spot market. Even though the number of LNG tankers built on a speculative basis is growing, its development is very limited due principally to the cost of LNG tankers in conjunction with uncertainties and lead time in LNG projects, shortage in spare volumes and the risks in the open market.

The existence of uncommitted LNG tankers in the gas market will be forced rather than built on design. Reported by Hedge (2004), Nick Roos Managing Director of Asset Finance and Leasing for Deutsche Bank, said:

> *LNG vessel financing still tends to be geared around the strength of the project and this is unlikely to change for the vast majority of newbuilds. Accordingly, if a spot market develops it will primarily be served by older vessels seeking employment at maturity of their initial charters and where debt levels are relatively low* (Hegde, 2005, p.56).

[14] In the long-term contract, suppliers are bound to deliver the quantity required in the contract despite the uncertainties that may occur in the LNG supply facilities or other technical uncertainties.

In fact, the involvement of certain independent shipping companies in LNG tankers does not reflect the strategy to invest in a free market as much it reflects the unwillingness of gas majors to bear the transportation costs. In most cases, their new liquidity in shipping is secured in advance by long-term time charter contracts. This appears to be the case of the following shipping companies: Höegh, Ceres LNG shipping, and Thenamaris, which has started to operate in the LNG shipping market. These companies affirm that the idea to invest in a free LNG shipping market is still unconceivable, and perceive that the spot market is still small, risky and closed to create any incentives. The persistence of long-term contracts in the LNG market will systematically provide no impetus to tackle the risks in the spot market in spite of the expected steady growth of the LNG spot market in the future.

Beside these differences with the oil market, which is totally open and relatively stimulates newcomers to play in shipping, other factors such as the age and the size of LNG tankers show dissimilarities? So far, only 12 vessels have been scrapped including 4 in 2008 where the age of the fleet is spread over 40 years (BRS, 2009). The difficulty to find employment for LNG tankers in the spot market will certainly give rise to scrapping, or to resort to other solutions to resist the high operating costs during dead business periods. However, the lifespan of ships may reduce the growth of the demolition market. If any scrapping market will evolve in the future, this will not appear for several years, at least, as about 64% of the vessels have been delivered within the short period of 8 years since 2001. When it occurs, the scrapping cycle will be longer than that of oil tankers and the dynamism in renewing ships will be slower.

Also, the very specific terminals to receive LNG tankers and the rapid trend towards large vessels are another impediment on the flow of LNG volumes in the spot market. Not all ships can access all ports. The size of LNG vessels is getting larger and the new generation of Q-flex and Q-max vessels is only suitable for very limited destinations. By contrast, oil shipping started with several small tankers accessing almost all ports in the vicinity and in remote markets. These tankers sometimes did not require any specific berths apart from underground pipelines, which allowed the use of simple berths designed for other cargo than oil. The flexibility in accessing ports combined with the small size of oil tankers encouraged shipping companies to invest in the spot market and to find easily sources of finance.

4.8.5 Product Specification Restrictions

The LNG product is considered as a product with no derivatives. This makes the LNG market restricted to one market compared with the oil markets. The difference is that oil market has developed several submarkets from its derivatives and only small quantities from each product are sometimes required, which automatically calls for the necessity of oil spot markets and therefore, more opportunities are created for oil transportation. The advantage in the oil shipping is seen in the more possibilities than in LNG shipping to carry a diversity of products as they are compatible. In addition, two or three products may be carried at the same time giving another advantage to oil tankers to exploit the maximum opportunities when they occur.

Another issue in LNG specificity is that its quality differs from one source to another, and requirements from local regulations and equipment to burn it may restrict the choice to acquire LNG from different sources. Rich hydrocarbons content in gas may affect the operation of gas burning appliances or equipment. The appliances in different countries tend to be tuned for the gas specifications prevalent in that state to prevent incomplete combustion. Specifications usually define an acceptable operating envelope; otherwise quality adjustment is required to ensure they are acceptable. The fact that not all terminals or LNG liquefaction plants are fitted with equipment to adjust the quality (it needs an additional investment) in 0accordance to the consumer specification (Hull, 2008) may be considered as a constraint to the development of the spot market as well.

CHAPTER V
ASSESSMENT OF OPPORTUNITIES AND RISKS IN THE GAS AND LNG SPOT MARKETS

Potential Implications for Algeria

5.1. Introduction

The development of short-term/spot gas markets has brought a number of benefits to both buyers and sellers and the wider LNG and gas industries. The flexibility provided by the short-term contracts enables, on the one hand, buyers to secure their supplies, to stimulate competition and to benefit from arbitrage in FOB contracts. Sellers, on the other hand, take the advantage from these contracts in the price difference between the different gas markets and free them from the rigidity of certain clauses existing in the long-term contracts. With these simple contracts concluded in a new environment of high gas prices and high technology that facilitate and entice production and reception of gas, the gas business attracts more players to participate in this sector, allowing new ventures to create new businesses and sellers to expand their production.

In contrast, the short-term/spot contracts present different risks to buyers and sellers alike. Algeria, as one of the gas exporting countries, is exposed to these risks in its gas market and its national LNG shipping. The fact is that it has chosen to operate exclusively with these flexible contracts after the expiration of the existing long-term contracts and in concluding any new contract as well. These risks are examined in depth in this thesis in order to be able to determine the fate of the Algerian new strategy in the spot market, the drawbacks in adventuring in such a risky market, and its impact on the Algerian national LNG shipping under the pressure of the open world market economy.

5.2. Buyers' Benefits in Portfolio Theory and Diversification

5.2.1 Security of Supply

With the growing risks in the imported hydrocarbons especially in Europe, the absolute necessity to hedge against their consequences on the economy is to resort to a concept that permits to secure adequate access at reasonable prices to energy imports in order to satisfy the needs of the economy (Lisbirel , 2008). The United Nations Development Program defines this concept of security of supply as "*The availability of energy at all times in various forms, in sufficient quantities, and at reasonable and/or affordable price*" (UNDP, 2004, p.42).

In the gas industry, security of supply is achieved by diversification, shortening contracts or purchasing LNG on cargo-by-cargo basis in order to create a portfolio, and to avoid the four risks in supply described by the Center for European Policy Studies (Behrens, March 2009) as follows:

- *Political Risks:* concern potential government decisions to curb or suspend deliveries because of deliberate policies, war or civil strife, or as a result of failed regulation.
- *Economic risks:* mainly cover imbalances between demand and supply, stemming from delays in investments in strategic projects or insufficient contracting.
- *Technical risks:* include systems failure owing to weather, lack of capital investment or generally poor conditions of the pipeline system.
- *Environmental risks:* describe the potential damage from accidents such as pipeline bursts. They also include other forms of pollution, the effects of which are less tangible or predictable (e.g. greenhouse gas emissions).

5.2. 2 Enhancement of Competition

An empirical analysis shows that among the factors that enhance a positive competitive effect on the market is a development of an active spot market (Dorigoni et al, April 2009). The LNG spot market is a favorable environment for an accessible, integrated and competitive LNG market that attracts new buyers to enter the market in order to provide the best service and competitive price. Among these buyers are traders who have neither long-term access to production nor regasification capacity but operate in between in the wholesale natural gas market and as a third-party in the transportation segment. The benefit of third parties in the LNG trade is that they may improve overall efficiency and provide freedom of choice for gas consumers.

5.2.3 Arbitrage Opportunities in FOB Contracts

LNG contract prices are determined based on whether LNG is priced FOB or ex-ship (Maxwell & Zhu, 2008). By contrast to the traditionally-priced ex-ship contract where prices reflect downstream prices, the LNG contract prices are increasingly period FOB, i.e. delivered to the tanker at the export terminal. Such contracts in the LNG spot market give buyers greater flexibility regarding shipping costs and the ability to exploit profit opportunities through arbitrage (Maxwell & Zhu, 2008).

5.3 Sellers' Benefits in the LNG spot Market

Suppliers are also seeking greater portfolio diversification to lower risks and to stabilize their long-term financials, aiming to take advantage of the following factors in the open market.

5.3.1 Selecting the Market of Higher Netback

The disequilibrium in prices between regional gas markets affords opportunities in the spot trade to producers to direct freely the LNG towards terminals offering the highest margins. In the bundling contracts, sellers are tied to an oil-indexed LNG price, which in most cases does not reflect the real value of gas in the spot market. Moreover, the oil price is rated high these days compared with gas prices and the practice of hedging uncertainties in long-term contracts is more likely to favor buyers rather than sellers[15]. The ex-president of OPEC and Mine and Energy Minister of Algeria, Chakib Khelil, said to the European Energy Review Journal that the fair price of gas will be determined by the spot market and "*the indexation principles do not take the important evolution of the spot market into account*" perceived since 2005 (EER, July, 2008). Therefore, the choice to sell gas to the person who offers the best price is a strategy that motives gas and LNG producers to call for short-term contracts.

Furthermore, the inflexible terms in the long-term contracts are seen today to create obstacles for suppliers to discuss the fair price of gas. The Price Review Clauses make these contracts more difficult to adapt to the varying circumstances in the long run. If one of the two parties considers the terms are not really fair, that raises the problem of contractual stability and so, threatens the guaranteed supply. From the sellers` perspective, the changing gas environment will oblige them to revise prices, but this will be on the good will of buyers. Algeria is one of those countries who failed to renegotiate prices under the current changing energy data with its customers. As an example, price renegotiations between Algeria's national energy firm Sonatrach and the Spanish utility Gas Natural, which it supplies with 9 bcm/year of piped gas under one such long-term contract, reached an impasse in 2007. Sonatrach took the case to international arbitration in Paris, where it remains unresolved (MEES, March 10, 2008).

Another issue in the long-term contracts that had always been a source of conflict is the destination restrictions. On the one hand, the suppliers` insistence to include these clauses in the contract reflects their concerns, especially when buyers purchased gas from a low-priced gas market that would be resold to compete with them in high-price markets. Hence, the aim to sell gas directly to the final consumer

[15] Nowadays, the minimum price of gas is far to be reached to protect gas suppliers from low prices. Some contracts start to be renewed according to the current level of oil price, which is estimated today to have an equilibrium price of $90 per barrel as a fair price for oil, according to Chakib Khelil.

gives the opportunity to gas producers to control prices, since it allows them to negotiate different prices for different markets[16].

On the other hand, regional competition policies consider that the territorial restrictions are against the competition law that is established to build a free trade in the territory. For instance, the European Commission (EC), through Article 81 of the EU Treaty seeks to build a single European market that comprises also the gas market, but its planning seems to be difficult to achieve with these restrictions in the gas contracts, which intend to restrict the buyer`s choice of where in Europe the buyer can resell gas it has bought. The long negotiation between Algeria and the EC has led to a mechanism that splits profit by 50/50 (Profit Sharing Mechanism or PSM) if the LNG price obtained is higher than the price in the contract against the right to take the LNG to an alternative destination[17] (Gassi Touil: A failed partnership, October 2007). However, PSM in gas sales by pipelines remain hard to apply as pipeline gas can only be delivered to one location anyway, and once it is in the network, it is very difficult to say what gas goes where. The long-term agreements in gas pipelines and the PSM in the LNG trade are considered less attractive for sellers in cases when the free gas market shows more profit. Shortening contracts will avoid the inherent rigidity imposed by the long-term contract clauses.

5.3.2 Development of New Business

The expected increase in world gas demand and the consequent development of arbitrage operations based on price differentials makes investments in this sector increasingly interesting. Gas reserves in major exporting countries are either underexplored or underexploited and the probable high prices in the spot market may provide an incentive to think about this profitable business. Moreover, given the advanced technology in the value chain through the FPSO and FLNG assets, small

[16] That is why most of gas producers favor self-contracting, which provides a value added in the whole chain as well.

[17] The PSM in LNG contracts also raises questions of its legality according to Article 81 of the EC as it can prevent or discourage buyers from selling gas to customers in other countries.

ventures may pop up to operate in the free market since the development of gas fields through these facilities is cheaper and quicker.

In addition, motives in the clarity and the supple form of short term contracts ease their integration in the gas market Wirya-Simunovic & Mumme, 2007). The majority of short term deals only require counterparties to agree the remaining terms such as price, volume, quality, delivery, location and other special terms which they are able to quickly discuss and then formalize. Shorter-term agreements have, at times, been completed in less than a week. Establishing Master Sale and Purchase Agreements, contracts which allow buyers and sellers to transact in the future having previously agreed most of the numerous lengthy standard terms, have greatly assisted quicker execution.

5.4 Potential Risks in the Spot Market

Resorting to a short-term trade in the gas and LNG market provides certain advantages for both producers and consumers in matters of flexibility, security and arbitrage, but this does not prevent them from being exposed to certain risks. The convergence towards a global gas market and the potential surge in demand of LNG spare volumes will create a more competitive trade that will end in a volatile price and less legible, opaque and more instable LNG market. Mazighi Ahmed (2004a) from Sonatrach reveals a less optimistic view about the efficiency of a short-term gas market, worrying that the flexibility does not rhyme with the volatility that may lead to amplifying risks in the gas market. He added that the costs of stock facilities, that necessarily have to exist in the spot market to face price uncertainties, may give an additional margin to the gas price, which will at the end be at the expense of the final consumer. Other analysts, such as Chidinma (2004) and Jensen (2004), emphasize the effect of the spot market on financing projects which suppliers will encounter if such a development in the gas market will occur in the future.

5.4.1 The Risk of Price Uncertainties

The modulated price risk in the traditional contracts in LNG is now a major risk under the new model of contracts. The negotiated contract was previously discussed to fix the price in the "money of the day", indexed to the crude oil price. The "S-curve" mechanism was often agreed upon to protect the respective parties from the impact of extreme volatility in crude oil prices. However, the emerging spot market has aggravated the price risk, because now natural gas prices fluctuate based on gas market supply and demand. Therefore, through the excessive price volatility in the LNG spot and futures market, the transactions in the short term will intensify risks.

The historical price fluctuations in the LNG spot market compared with the oil-indexed gas price often shows that the former was higher than the latter. This difference reflects the level of incertainty that characterizes trade in the spot market caused by lack of liquidity in a certain organized market, possible repercussion of prices of electricity when the market of gas and electricity are imbalanced, efficiency problems and information retention (Mazighi, 2004a).. Against this situation, producers who are more keen on the stability of cash flow prefer the indexation of gas price. Also, the drawbacks of gas price volatility may cause damage to final consumers if it increases the prices of certain hedging instruments such as ``Call`` options. In contrast, the gas industry today witnesses very low prices[18]under the economic regression, as such discouraging suppliers to put more spare LNG volumes into this uncertain market, especially if the financial crisis will endure for a long time.

5.4.2 The Risk of Gas Storage Costs

The gas price differential between different regions will convey LNG volumes to the market, which offers the highest price. Consequently, the only way to respond to the

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[18] The price of gas in the Henry Hub is 3.48$/MMbtu as of July 27, 2009 compared with 13.3$/MMbtu one year ago.

gas volume variation in the countries that offer a relatively low price for imported gas is to have the available gas in stock, or to be interconnected to places where they show no deficiency in gas. Building such infrastructures needs huge investment to secure gas supply. According to Mazighi, storing gas in salt cavities, depleted fields or aquifers can cost 75% of the cost of LNG through the value chain (Liquefaction, Shipping, Regasification) (IEIM, April 2006). This means that what is gained from lowering price by storing gas is automatically lost through the costs of storage infrastructure. Table 5.1 illustrates the costs affecting the downstream.

In the upstream, the storage issue can also arise if they want to manage gas stocks to control the gas price. The storage of LNG or natural gas in the long term plays a pure logistical or operational role whereas in the short term it absorbs the uncertainties between demand and supply. So, this additional cost to the value chain will also affect the gas price that the final consumer will bear at the end.

Table 5.1: Storage facilities costs.

	Min ($/MMbtu)	**Max ($/MMbtu)**
Development cost (Liquefaction, Shipping, Regasification) [19]	3	4
Storage cost(1MMbtu) in salt cavities	0.9	3.3
Storagecost(1MMbtu) depleted fields or aquifers.	0.5	0.8

Source: Mazighi, 2004b.

5.4.3 LNG Volumes Risks

Two possible scenarios can occur in the LNG market that may create risks in the development of the spot market. The first occurs when little volumes are available leading to competition between buyers to acquire this fuel, and the second occurs when this trend is reversed. Depending on how the balance of demand and supply

[19] Production capacity of 6 to 9 BCM /year

will vary in the future, the following will analyze the probable paradigms that may affect the LNG spot market.

5.4.3.1 Scenario 1: High demand/ Low supply

In Scenario 1, gas supply is projected to be very tight, and satisfying the demand growth in the long term will be difficult. In addition, the uncertainties from time to time will certainly further aggravate the procurement of this fuel leading to higher gas prices, or simply, it will make the spare LNG volumes unavailable in the spot market. Unpredictable events, such as the reduction in nuclear power capacity in Japan, a lack of rainfall in Spain, the sudden advent of cold weather in Europe and Asia, and the hurricanes that frequently hit the US can result in significant deviations of LNG demand from one region to another, thereby pushing the LNG prices up.

Moreover, political reasons can affect supplies considerably in the traditional or emerging LNG consuming countries. The political instability in West Africa and the Middle East raises questions about whether gas producers in the region will be able to turn into reliable exporters. The continuous political unrest that threatens the Nigerian LNG facilities and the future projects increased dramatically while Iran's regular confrontations with the West on various issues does not send out positive signals. Qatar is also supposed to become a major LNG exporter, but internal political strains should not be underestimated when it comes to gas exports (Checchi, Bahrens & Egenhofer, 2009). In North Africa, Checchi et al (2009) along with Palm (2007) reported that Algeria came to see relative political stability in the last decade, but internal upheavals and conflicts are akin to a civil war whereas the potential from the other emerging gas-producing countries may be difficult to predict.

Adding to these uncertainties, technical problems and the expected decrease in LNG production in some regions are also determinants in creating imbalance between demand and supply. For example, the year of 2008 recognized many disruptions in LNG facilities in Nigeria, Norway and Algeria which influenced the gas procurement of certain countries such as the US and certain European countries. Moreover, many

LNG projects that were expected to come on stream have been delayed restraining more the production of LNG. In the long run, the progressive exhaustion of European indigenous gas supply on the one hand and the Indonesian policy to cut off LNG exports to secure local supply, plus the increased local consumption of gas-exporting countries on the other hand, will aggravate the shortage in gas supply.

As a consequence of the shortage in LNG volumes, it will drive the LNG tankers, gambling in the spot market, to operate with low utilization rates and with very low charter rates as is the case today[20]. A London broker said, "*Charterers should remember that long-term low rates mean owners are not investing in LNG. Nothing has been ordered since April 2008 and without new investment all the spot ships will go on to project work*" (Wingrove, May 14, 2009).

So, the combination of these uncertainties that may occur in the short and long-term can make the LNG volumes in the spot market very tight, threatening both consumers who rely heavily on the LNG spot market, and the independent ship-owners who have taken the risk to invest in this business. The spot market is uncertain and very risky, and the need for security of supply and stable cash flow for shipowners seem to be a necessity. Accordingly, the EC is oriented in this sense to acquire a stable supply of energy in the long run. One of the top priorities of the EU is the assurance of stable gas procurement from Algeria, Nigeria, and from other planned projects such as Nabucco and Trans-Caspian pipeline gas. The countries which rely heavily on the LNG market such as Japan and South Korea will also not take a risk to depend on the volatility of the LNG in the spot market.

As a conclusion, there is little evidence that the LNG spot market will expand greatly for two reasons. The first is that the security of supply is a necessity for consumers and the need for stability is a priority. The second is that the LNG will probably lose

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[20] Charter rates on the spot market were around US$28,000 per day-US$30,000 per day as of May 20th, 2009 compared with $63,000 per day with less volatility during the year of 2007.

out as it is a rather high-cost alternative as of today, and the incumbent investment in the upstream will provide a disincentive for suppliers to take the risk in an uncertain market. In fact, the need for spare volumes to cope with the short-term uncertainties and the willingness of certain LNG providers to profit from arbitrage may give reasons to resort to short-term contracts, but this trend, if it occurs, will certainly grow in tandem with the existence of long-term contracts.

5.4.3.2 Scenario 2: Low demand/ High supply

Even though experts give a low probability for this scenario to happen in the long run, this does not mean that no similar occurrences will take place in the short run. Events such as the economic turmoil are factors that have ascertained this trend many times in the past. The economic recession seen these days has forced suppliers to either sell their gas with low prices or to wait for further improvement in the gas market. Consequently, the instability of cash flow in the spot market may affect deeply the producing countries who try to direct their gas sales to the open market, and especially if their economy relies heavily on the gas export. When in the first scenario the imbalance between gas demand and supply favors suppliers to operate in the open market, in the second scenario, the oversupply of gas will lead to weakening the market power of suppliers and the hope to consider the long term contracts, or at least the medium-term contracts in this case will shift from buyers to sellers.

Furthermore, what technology can offer in the forthcoming years may contradict the experts` expectations who bet on scenario 1. The shift from gas to another source of energy may reduce demand considerably, especially in the case of high prices. For instance, in 2008 when the price of gas was high, the US satisfied its local gas demand considerably by exploiting their shale gas resources; however, so far they are still considered costly to exploit compared with the conventional gas (ANALYSIS-Market elusive for U.S, February 4, 2009; Reuters Summit-Kinder, June 2009). In Britain, the higher gas prices have already led to a move from gas to other energy sources in new generation capacity (Palm, 2007). Also, substituting gas in power generation by nuclear power and new less polluting coal plants is possible in case of high prices[21]. Hence, the role of technology may provide a solution for exploiting local non-conventional gas sources, or provide better solutions for other types of energy, which may reduce gas demand and create surplus in gas volumes in the LNG market.

This surplus will also originate from the development of different gas sources that are planned or coming on stream in the years to come. Regardless of the short-term uncertainties, the planned increase in LNG volumes from Iran, Nigeria, Algeria Angola, Australia and other new emerging LNG producers, such as Venezuela and Egypt, will offset the equilibrium between supply and demand. Russia, which is planning to penetrate the Asian-Pacific market through the Arctic routes (Americanshippers, October 2008, p.75; Gray, June 30, 2009), it has started to participate in the value chain of production, delivery and export of liquefied gas. Based on the extensive resources of the Arctic seas shelf (especially the Shtokman field), Gazprom is now actively investing in plants for production of liquefied gas (Korosteleva, 2008). The strategy of China towards gas demand is also uncertain. This country relies heavily on coal and the solution for less polluting coal is a reality in case of high gas price[22]. So, a possibility of oversupplying the gas market with LNG volumes exists, especially if demand does not fulfill the expectations of IEA and other analysts.

In conclusion, there is no assurance that LNG demand will outstrip supply for the reasons that probable changes in technology may drive gas supply to develop faster than gas demand in the long term, and, consequently, the LNG spot market remains uncertain for sellers. In this scenario, driven by these expectations, the open market will lose its strength and the capital-intensive projects may deter to suppliers from

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[21] New technology which reduces particle and NO_x emissions is being developed and tested. Carbon capture technology is also being developed for coal fired plants.
[22]Coal remains the cheapest fuel despite the extra expenditures for making it cleaner.

investing in LNG projects. The LNG market will only develop as niche markets that favor long term contracts. The oligopoly seen in scenario 1 will be abolished in the scenario 2 to allow competition occurring between many suppliers rather than between buyers. The result will be less flow in LNG with an emphasis on long term contracts driving the prices downwards.

5.4.4 Financial investment Risks

One of the most challenging developments in recent years has been not just the growth of the spot market in LNG but also the need for lenders to accommodate the sellers' and buyers' requirements for more flexibility in LNG transactions. The whole LNG chain is capital intensive and has a long gestation period. Lenders usually do not find any difficulty to finance an LNG project since a stable cash flow is guaranteed by the sale and purchase agreements traditionally concluded in the long-term contracts. With the recent advent of a spot market, this traditional project financing structure whose exclusivity contracts and destination restriction clauses are proving to be too stringent for the parties involved, and thus the need for flexibility in financing structure has become important.

To finance an LNG project, lenders generally investigate the main risks and categorize issues that need to be addressed into four broad areas: upstream; midstream; shipping and offtake (Chidinma, 2004). .

5.4.4.1 LNG Upstream and Midstream Financial Risks

In the upstream, concerns about the security of the gas supply pushes lenders to require insurance about the effective availability of gas reserves from those who are in charge of the upstream development. Lenders also need confirmation that competent operators will develop the gas reserves in time for the project to effectively take off. In the midstream, the completion of the gas gathering, central gas processing and the liquefaction facilities (the most expensive part of the chain) has to be considered carefully since the construction period is the time of greatest risk to a lender to an LNG project.

5.4.4.2 Shipping Financial Risk

In financing LNG vessels, lenders will want to review many aspects. Construction is one of its risks that has to comply with international standards in construction materials. Other requirements, such as international maritime law, have to be considered to guarantee lenders the life of the vessel and to make it fit for safety. Moreover, political risks, technical risks, routes, physical risks in both ports and force majeure are factors that may influence the lenders' decisions to finance vessels where an insurance coverage for these risks may present a solution for them to secure their payback. Security and environmental risks are also counted as important parameters in the lenders' credit appraisal, even though there has not been any accident that may provoke such a fear.

Generally, the financial schedule will remain the only aspect to consider once these exigencies are verified. Dedicated vessels in fact encourage lenders to provide funding for their construction since the whole LNG project shows a stable cash flow. However, financing LNG tankers, which are not committed for any LNG project, still find difficulties to convince financiers about their profitability.

Shipping in general is a risky business that is likened to "gambling". In the LNG spot market, less chartering opportunities are offered as the LNG shipping is still a closed market in which the majority of contracts are concluded for long term and for specific LNG projects. In addition, the price risk could be intimidating in vessel charter in the spot market, which may discourage lenders to support any venture in shipping. Eze (2006) reported that "Golar, the publicly traded company dedicated solely to LNG shipping, has gambled heavily on the growth of the spot market, but now looks to have taken a step back describing the short term market as 'disappointing'." As a result of low charter rates in the LNG spot market, no order has been made since April 2008 (Wingrove, May 11, 2009).

5.4.4.3 Sales and Underinvestment Risks

The LNG value chain is a burdensome investment for buyers and sellers who agree to share the risks in long-term contracts by allocating equally their resources in the project for their mutual benefits, or by guarantying sales from buyers for a long period. In this agreement, the parties assure the income stability by the sale and purchase agreements that are favored by financiers, but in detriment of more opportunities in making profit and reducing costs. This stability has been threatened when a different mechanism in trading LNG emerges. By choosing to operate in the spot market, the burden of investment has shifted from buyers to sellers as the upstream and midstream consist of the high investment costs. Shipping is also shifted to the charge of sellers in most cases to assure the LNG transportation, if any new project should come on stream (see Figure 5.1).

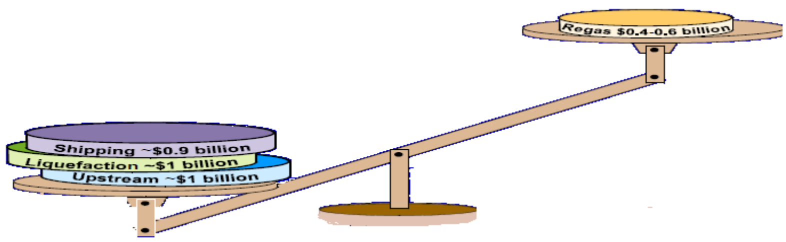

Figure 5.1: The Shift of Financial Risk From Buyers to Sellers
Source: Mazighi, June 2004b.

Introducing the notion of ``unbundling” in the LNG project investment makes a difference in the efficiency of different activity levels in the segments of the LNG value chain. The upstream, the most vital sector, becomes relatively less efficient compared with other sectors, which can be threatened with a risk of “underinvestment” (Mazighi, 2004a). Moreover, sales become uncertain and this is the source of bankers` concerns for the recovery of their loan (Chidinma, 2004). So, the development of the LNG spot market will depend on the acceptance of lenders to adapt to the change and take the risks in financing the upstream and midstream projects (Tayal & Garg, 2009). Otherwise, behind this risk incumbent on sellers, all the physical gas market liquidity will be affected.

5.5 Potential Implications of the Algerian new Strategy in the Gas Spot Market

5.5.1 Algerian Transitional Strategies in the Gas and LNG

The market of oil and gas forms the heart of the Algerian economy. More than 98 % of the total Algerian revenues rest on exporting hydrocarbons in which gas and LNG are considered extremely sensitive and strategic resources to the extent that any instability in these markets may threaten the whole equilibrium of the Algerian economy.

Since the Algerian independence in 1962, the State had governed a policy of pure nationalism in matters of economy until the end of the 1980's. Since then, Algeria tried to adapt to the fundamental changes in the underlying dynamics of the natural gas and LNG industry, and made two major decisions in the gas sector. The first decision led to a change in its policy when the Algerian parliament voted for the law of hydrocarbons in 1991, which gave for the first time a permissible environment to foreign companies to invest in gas. After 25 years of refuting the idea of "joint-venture", thereby depriving the country of the benefit from technological contribution, the propensity to collaborate with big IOCs becomes nowadays an indispensable policy in nearly all the Algerian transactions in the gas and LNG markets.

However, the attitude of Algerians towards the open market economy[23] presents difficulties to attract foreign investments in the gas market while its gas resources are considered to be "under-explored" (Guangshuan, June 2009).. The EC has put Algeria under pressure to change its strategy with regard to the new Algerian governmental decisions[24] that came into effect in 2009, and insists that Algeria has

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[23] According to international institutions, Algeria was classified, in a conference held on July19th, 2009, the last in Africa in matters of open economy.

[24] Any investment in Algeria must be majority-owned (51%) by Algerian companies, individuals or entities, and new foreign import companies must demonstrate a 30 percent minimum Algerian partnership effective March 1, 2009. The EC considers these arrangements to be contrary to international law.

to adapt to the new world strategy in gas and energy in order to avoid considerable losses (Benhamla, July 19, 2009). .

The second notable decision came when Mr Chakib Khelil declared that Algiers would not sign long-term contracts anymore, arguing that the surging value of oil is not fairly reflected in the long-term LNG and piped gas sales contracts that it has with its customers (Maclean, April 30, 2008). On one hand, this strategy seeks for commercial flexibility with the aim to optimize revenues in the gas spot market and to make profit in arbitrage opportunities. An analyst from Sonatrach affirmed this policy by saying: *"We don't like long-term contracts. We prefer mid-term contracts, of up to five years, and short-term contracts, or master sales agreements, which we can sign for one year, where we sell on a cargo-by-cargo basis* (MEES, March 10, 2008).

On the other hand, this strategy aims to free the government from any binding clauses and duration of long-term contracts. Chakib Khelil assumes that in the long-term contracts *"the Algerian party is at the mercy of the buyer"*. He added that there are no clauses in the long-term contract that "…*have the option to terminate the contract, except to wait for another 15 years to do so, while in a short-term contract, it suffices to wait just a year or two to renegotiate the price in an open and transparent manner*(MEES, March 10, 2008).

Along with these two objectives, the government intends to increase the national LNG fleet in order to meet the likely changes in the LNG spot market. Expressed by the tongue of Dr Chakib Khelil, Algeria seeks to reach, at least, the transport of 50% of its LNG by the national company (HYPROC, 2005, February).. Moreover, Algeria looks for better utilization of its LNG fleet in the spot market. This trend is seen in the two LNG tankers "Medmax", which are designed to operate in the open market fitted with equipment compatible to load and unload LNG from the major world LNG terminals in the world.

5.5.2 Risk Evaluation of the new Algerian Strategy

5.5.2.1 Repercussions of the Algerian Strategy on Europe

Algeria, a gas provider of quality, has long been the most reassuring and reliable country that delivers about 90% of its gas quantities to Europe with “goodwill”. Most of the delivered volumes have been based on long-term contracts. Its proximity to South Europe gives Algeria the advantage to benefit from low costs of transportation and a privileged position in competition with other suppliers. The vulnerable supplies from Russia, especially with many geopolitical crisis occurrences with Ukraine which on many occasions left Europe short on gas, have reinforced its position as a solution to Europe to diversify its gas imports and to reduce its reliance on one supplier. However, following the Algero-Spanish conflicts about the reopening of the long-term contracts concluded in 1995 in order to revise gas prices, Algeria has started to lose this confidence in the European market where Spain tries to look for other suppliers such as Gazprom to reduce its dependency on Algeria.

The shock to the EC was also felt by the conflict of interests between Algeria and the EC after the announcement of Algeria to shorten its gas contracts, as such threatening the stability of supply to Europe. While the EC is trying with liberalization to achieve low gas prices by creating internal and external competition between the traditional suppliers and the European buyers, gas suppliers who have chosen to operate in the spot market may, however, send their gas far from Europe (LNG possibility) or not sell it until it will be fairly evaluated (in case of gas pipeline). In fact, this is what Algeria is seeking from the spot market. Chakib Khelil has stated clearly that the security of supply to Europe has a price to pay. He ascertained that with a short-term contract, Algeria gets power to decide about the price at which to sell its gas (EER, July 2008).

5.5.2.2 Repercussions of the LNG Spot Market on Algeria

According to the Algerian new strategy, it seems that Algeria is clearly very confident that it will not struggle to find buyers for its gas on a short-term basis.

However, the global recession has seen a dramatic reduction in demand for energy as industries and consumers tighten their belts. The discrepancy between supply and demand for LNG looks likely to persist, with still more LNG production and liquefaction facilities coming on line and no certainty of when demand will revive to require the use of this new capacity. The volatility of energy prices in the spot market can drive the Algerian economy to collapse. Jonathan Stern, Director of Gas Research at the Oxford Institute of Energy Studies said

> *While I can understand the Algerians' frustrations…I'm not sure that short-term gas contracts will serve them well in the longer term". He said, "I'm also uncertain that they will have substantial additional volumes of gas to sell any time soon, so this may make the question (of whether the new Algerian policy is a sensible one) academic*" (MEES, March 10, 2008). .

This strategy also relies heavily on the theory that demand will lastingly outstrip supply. This assumption has also been demonstrated to be unreliable in the long run as presented and analyzed in the scenario 2 as analyzed above, due to the fact that technology advances may bring surprises in the energy sector. Also, high prices in gas may lead consumers to shift from gas consumption to other types of energy, which may create an oversupply of gas and LNG in international markets. This will be intensified if the other suppliers' strategies follow the same policy of the Algerians. Consequently, the gas industry may see low gas prices and surplus in LNG volumes traded in the spot market.

In addition, buyers' policy will always search for stability of supply as this fuel is very sensitive to consumers, which means that long-term contracts will be favored, and only volatile gas volumes may be targeted for the spot market. The Algerian gas export, which depends almost totally on Europe, becomes vulnerable to any change in the EC policy as a result of the Algerian strategy to adopt short term contracts. Different existing and potential competitors who can provide reliability and stability of supply may threaten the Algerian position in the European market.

Concerning the consequence of the LNG spot market on financing the Algerian LNG projects, the government seems to be less concerned about this issue. While others are struggling to secure loans to finance their projects, Sonatrach uses its own cash and rarely resorts to banks. The CEO affirmed that

> *The decision on projects is taken according to our financial situation. On the national level, we finance our projects using our cash flow or through Algerian banks, whereas for international projects, we also use our cash flow or banks, but generally we look case by case and we mainly use our own resources to finance our projects* (Henni, July 15, 2009).

However, this solution may not be as efficient as acquiring foreign loans to finance projects, and evokes many questions about its limitations as well.

5.5.2.3 Repercussions on the National Shipping Company

The Algerian decision to increase the national LNG fleet comes from the presumption that Algeria will get a power position in the LNG spot market. The Algerian objectives seek from its planning to first, assure the transportation of the potential LNG volumes destined to the LNG open market and second, it aims to create an added value in the LNG chain. In fact, Algeria tries to protect its interests in the transportation policy to comply with the Article1 of Algerian Law No. 78-02 of February 11, 1978, that gives the state a monopoly on foreign trade. It reads, "*In accordance with the provisions of the national charter and applying Article 14 of the Constitution, the import and export of goods, supplies and services of all kinds are under the exclusive control of the state*.`` (OTA, October 1983, p.206)[25].

[25] Algeria wants to require a 50-percent clause in its export contracts for liquefied natural gas (LNG) that gives preference to Algerian-flag vessels.

This tendency will certainly be in contradiction with buyers' interests who are increasingly calling for flexible contracts to control the resale of excess cargoes and to reduce shipping costs with the ability to exploit profit opportunities through arbitrage. This attitude of protectionism followed by Algeria in transportation also seems to contravene the principles of the open market economy, and the EC is now trying to convince the Algerian government to give up its old nationalistic inclination. Thus, the national companies will be deprived of any protection, usually embodied in the LNG sales, if it shows a desire to comply with the free market economy rules and competition law.

In this case, operating in the free LNG shipping market will not be an easy task if the ideology of protectionism starts to fade. The Economic and Social Commission for Asia and the Pacific (ESCAP) stated in its study that: "*National Shipping fleet(s) that are not internationally competitive and cannot match the freight rates or service levels of overseas shipping lines will not be able to survive in a free market*." (ESCAP, Nov 16, 2004). Sonatrach has already experienced a similar scenario in the oil market where the national shipping proved unsuccessful, revealing its inability to compete with independent and private shipping companies and by the end, resorting to third parties so as to reduce costs of transportation. With reference to the low freight rates that the LNG shipping is witnessing today, the pressure from the international community on Algeria, its effect on the LNG transportation, and the risks in the LNG market and LNG shipping, the author suggests that Algeria should carefully reconsider its strategy with a further vision.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6. 1 Summary and Conclusions

In this dissertation, the reader has been guided through the current topics in the contemporary development of gas and LNG markets and it has demonstrated the role of the technological advances in enhancing this development. An effort has been made to examine the evolution of the gas and LNG spot markets by considering the changes in the traditional way of contracting and trading gas and the risks that may affect both suppliers and consumers. Moreover, an attempt has been made to define the Algerian gas and LNG markets and assess the likely risks that Algeria can face in its gas industry when operating in the spot market. This study has come to a number of conclusions about the future of the LNG spot market and its implications for the Algerian gas industry. Among the major conclusions are:

1) The propensity towards gas consumption is sustained by its dual advantages of having relatively low environmental impact and being an economically effective alternative solution. When the first advantage is a fixed parameter that is inherent in the specification of the fuel, the second advantage is a variant that changes according to what technological breakthroughs can achieve to reduce costs in its production and transportation. Therefore, the evolution of gas and LNG trade in the long run will depend mainly on how the advances in technology will advance such benefits to favor

- the gas development against other types of existing or potential energy (coal, fuel, nuclear, renewable energy);
- the conventional gas against the nonconventional gas;
- the development of the traditional techniques in transporting gas with respect to new techniques, which start to appear or are being studied.

2) The current trend in energy development indicates that the technical and economic advantages are today allowing the associated and non-associated gas to be the conventional traded gas, and the reduction in its production and transportation costs has helped many new players in the gas and LNG markets to emerge. In the short and medium term, many gas projects are expected to come on stream. The LNG business seems to encourage newcomers as well as some traditional gas producers and consumers to go for this market due to the flexibility and some benefits that it may offer, as such making the LNG development grow faster than gas pipelines.

3) The majority of experts expect that gas demand will outstrip supply and more LNG will be needed beyond 2013; the year when the major consumers will see resurgence in energy consumption after the current economic crisis, whereas few LNG projects will appear on the horizon. Downstream facilities, as a consequence, are developing faster than those of the upstream. The unbundling of projects has favored this trend to provide buyers more flexibility and the freedom to choose where to buy gas with the possibility to face uncertainties with extra downstream capacity.

4) The two separate gas markets (Atlantic and Pacific Basins) are starting to interlace with LNG trade. This has been caused by the imbalance in demand/supply perceived recently and eased by the role of Qatar in the LNG market, and also, as a result of the policy of certain suppliers and traders to benefit from arbitrage.

5) The national and international environmental regulations are enhancing the development of LNG market by putting pressure on operators to adopt a strategy of “clean fuel”.

6) The gas industry is witnessing many changes in the commercial transactions. The investments in the value chain of gas and LNG projects are being dismantled, contracts are becoming shorter, gas prices are attempting to equilibrate in one global market independently from oil prices, and LNG tankers are being operated in a

speculative market. However, limitations and constraints in the inherent gas market will prevent the gas market from completely accommodating these trends.

7) The LNG short-term/spot market is developing rapidly. Similarities with the oil market evoke a perception that this market may evolve to operate with the similar patterns as those of the oil market, but the high costs of the LNG facilities, the need for long term planning and other inherent obstacles in the LNG infrastructures and the gas product will prevent the LNG short-term/spot market from developping identically with the oil market. So, the long-term contract will remain as the dominant relationship between buyer and seller and, although short-term volumes will continue to increase, the growth of the short-term market will only consist of a small proportion of the total trade.

8) Some benefits characterize the LNG spot market, but it remains very risky and uncertain for both gas producers and consumers, which can engender for them extra costs in storage, uncertainties in prices, risks from imbalance in supply/demand and financial investment deterrence. As stability in cash flow is a priority for an economy of a gas producing country that relies on gas income, similarly, security in supply is a prime concern for buyers who are very sensitive to the consumption of this fuel. This will encourage both of them to search for contracts that show stability in the long-term contracts but include certain flexibility.

9) Sellers will become disinterested in the gas and LNG spot market if supply outstrips demand and the same case will occur for buyers if supply is very tight. The LNG spot market is by its nature very volatile and the two above cited scenarios are possible in both the short and long term. Even though the second case is more likely to occur in the long run, the occurrence of the first case is not impossible as the technological breakthroughs may change the gas and LNG trade map.

10) The spot market is highly capital-intensive with substantial financial risks. The unbundling of projects allowed each party in the traditional rigid long-term

contract to assume its own project risk. Consequently, financial risk has effectively migrated upstream and since no project developer has been willing to launch a new project without some contract coverage to help manage that risk, the long-term contract will remain as the mainstay of the LNG business.

11) The Algerian gas industry has been improved by following the joint-venture strategy that helped keeping its proven reserves, production and transportation at acceptable levels. Algeria has also developed its gas trade by penetrating the downstream in order to be closer to the final consumer, thereby allowing a value added in the whole gas chain, security in demand, and better control of traded volumes.

12) Algeria, by deciding to operate in the spot market, has chosen to gamble in the market. The seemingly high profit from arbitrage and high gas spot prices seen recently has attracted Algeria to bet in this market. However, the drawbacks and risks that this market generates call for a wiser decision especially when the recent economic crisis proves that the spot market does not merit such an adventure if compared to the stability of cash flow that the Algerian economy so heavily depends on.

13) The repercussion of the Algerian strategy to operate in the spot market combined with the pressures of the world market economy may cause the national LNG shipping to lose its strength. The transportation of the Algerian LNG cargoes with Algerian flag vessels has usually been protected by the LNG sales contracts. Today, these routines are seen as unlawful by the EC and contrary to what the open market economy dictates to enhance competition. As a result, Algeria may face difficulties to compete with other private shipping companies that often provide better service and lower freight rates.

6.2 Recommendations for Algerian Strategy

- The choice to operate in the gas spot market is a solution that can be valid only for a short term. Algeria needs to reconsider its strategy in the gas industry taking into account the long-term planning.
- Algeria has to benefit from foreign technological contributions and expertise in the domain through partnership with major IOCs, and needs to integrate downstream in order to secure gas sales and control volumes.
- Establish a portfolio using a contract mix (long-term and short/spot contracts) by:
    - i) Signing long-term contracts of shorter periods of 10-15 years instead of 20-25 years for new projects; a sufficient period to encourage investment and financing projects.
    - ii) Renewing long-term contracts for 10 years or for medium term.
    - iii) Using the tools of renegotiation, price adjustment and review clauses when negotiating long-term contracts.
    - iv) Allowing a certain margin of capacities to the spot market (15-20 % of total capacity of a new project and 20-30% for a renewed one).
- Attract foreign investments by alleviating stiff regulations and resort to loans instead of using the entire cash flow in a gas or LNG project investment in order to reduce risks and to provide other investment opportunities in the oil and gas sector.
- Avoid investing in LNG tankers since the LNG shipping market still shows uncertainties, especially if the vessels are not committed to a project or otherwise unprotected by contracts of sales. Only LNG tankers that are intended to operate with self-contracted volumes may be rational and interesting investments for the national shipping company. Joint ventures with major IOCs in LNG shipping seem to be a good solution to share risks if LNG vessels are designed to operate in a promising LNG spot market.

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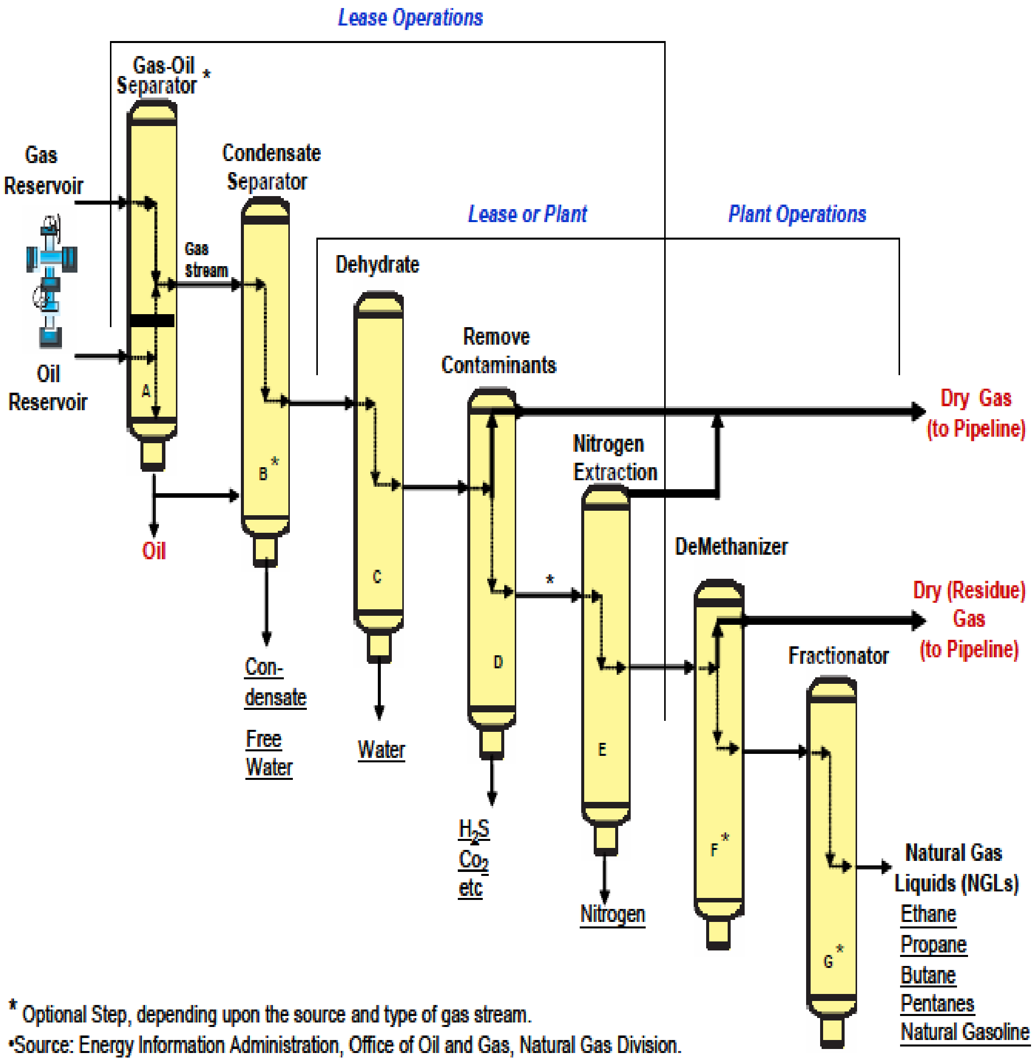
APPENDICES

APPENDIX A

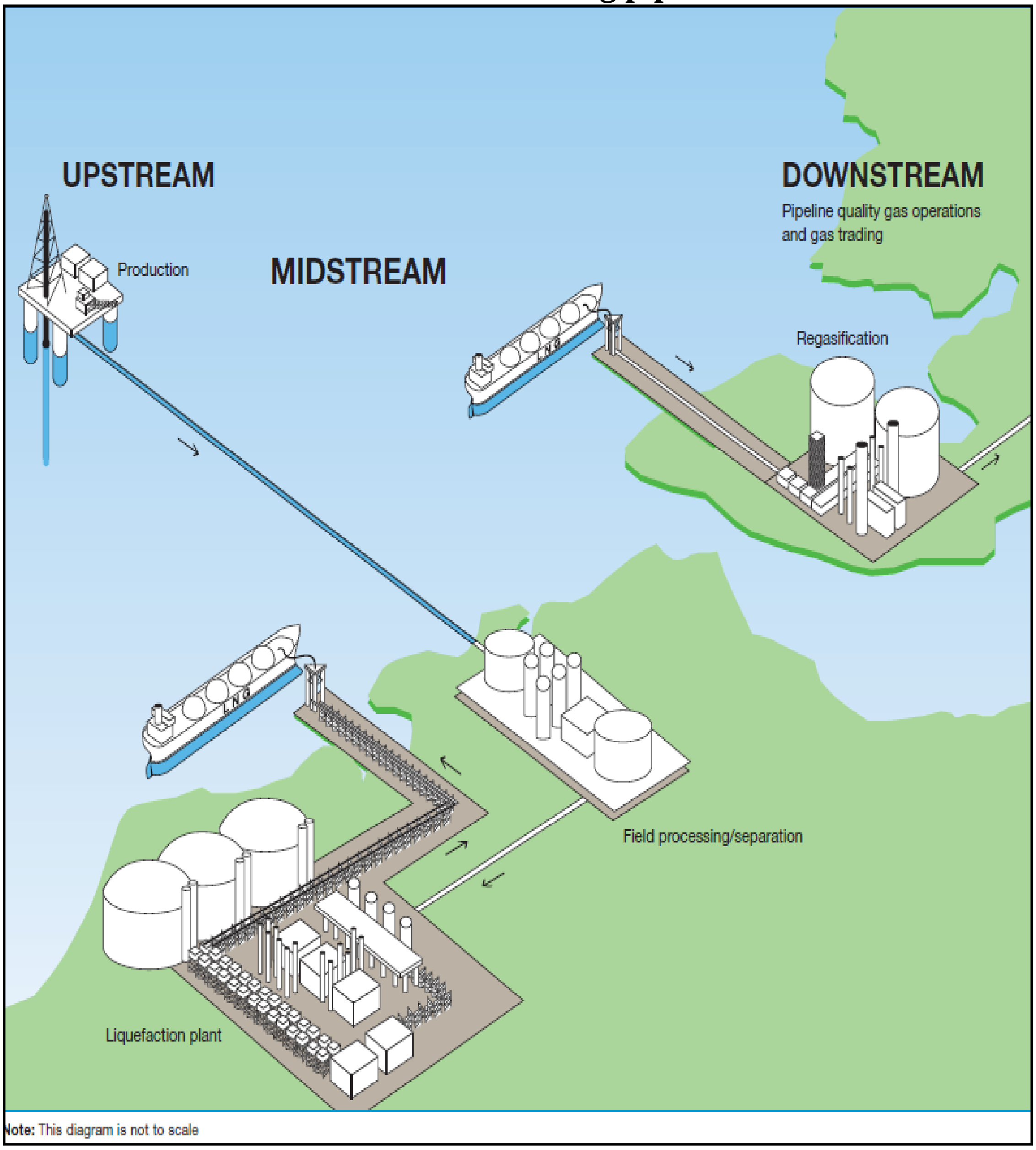
Generalized Natural Gas Processing Schematic



Source: Energy Information Administration, Ofice oil and Gas, Natural Gas Division, Jan, 2006.

APPENDIX B

LNG Chain : a Floating pipeline



Source: PriceWaterHouseCoopeers, (2007).

APPENDIX C

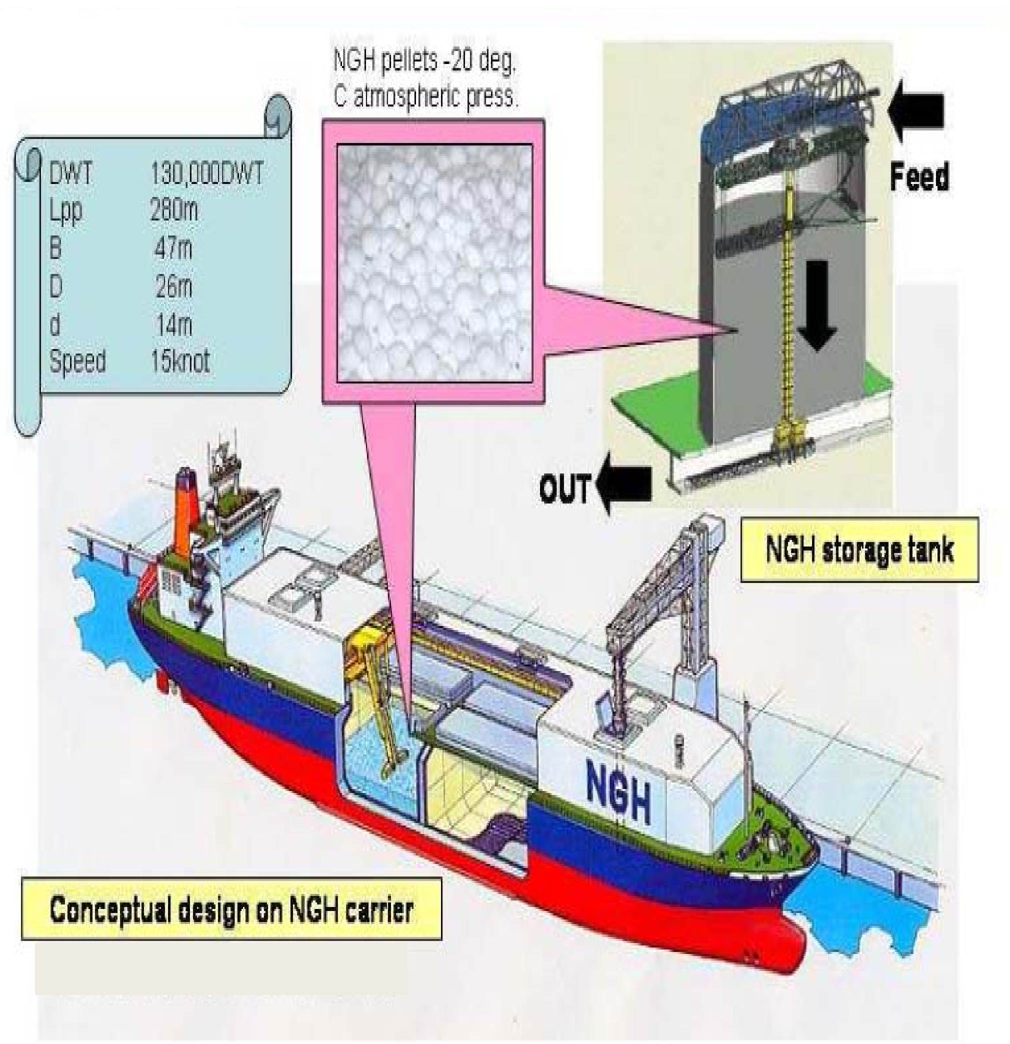
Comparison of natural gas delivery by LNG and CNG

	LNG	CNG
Proved/stranded gas (10^{12} $m^{3)}$	161	127
Capacity (milliom $m^{3)}$	100-250	1.4-22
Reach (km)	6000-12,000	200-5500
Upstream infra costs	very large	low
Downstream infra costs	very large	low
Number potential export sites	low	large
Global gas commodity market	no	yes
Energy balance delivered gas	very strong	strong
Public acceptance	low	unknown

Source: Biopact team. (2007, September 5). *A quick look at CNG ships.* Retrrieved on 15 July, 2009 from http://news.mongabay.com/bioenergy/2007/09/quick-look-at-cng ships.html

APPENDIX D

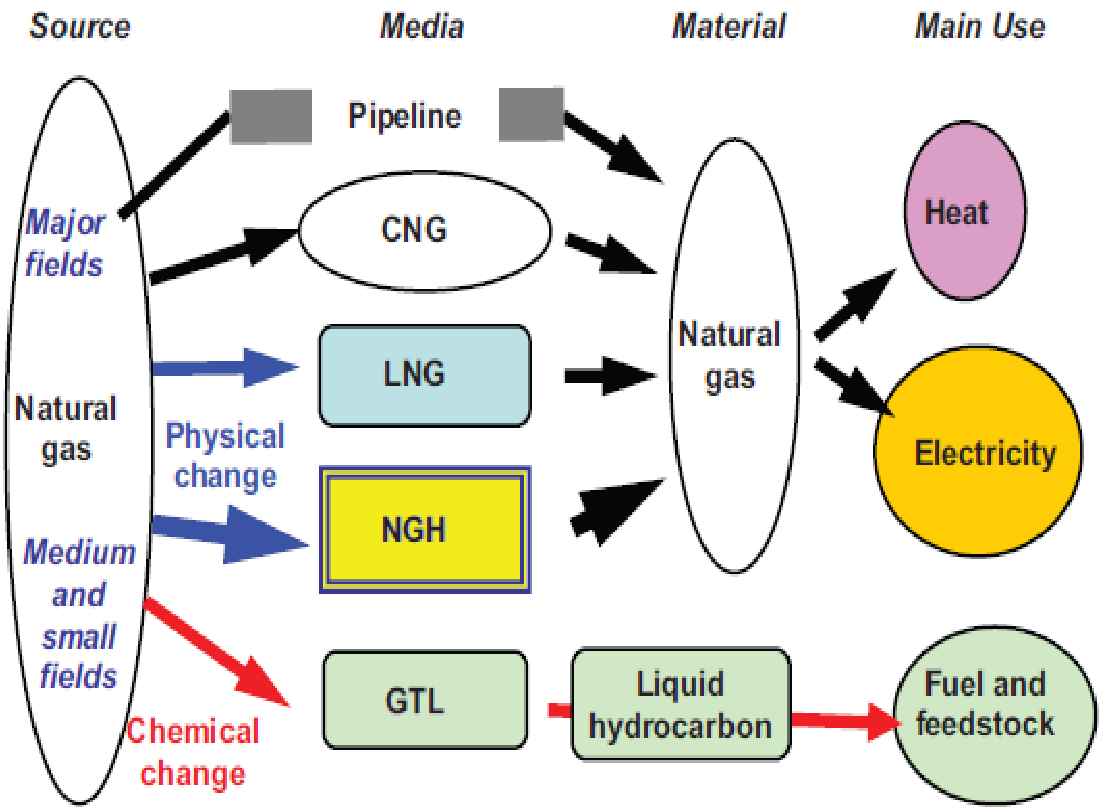
The transportation of natural gas by NGH



Source : Kanda, H, 2006.

APPENDIX E

The Concept of Transportation Gas



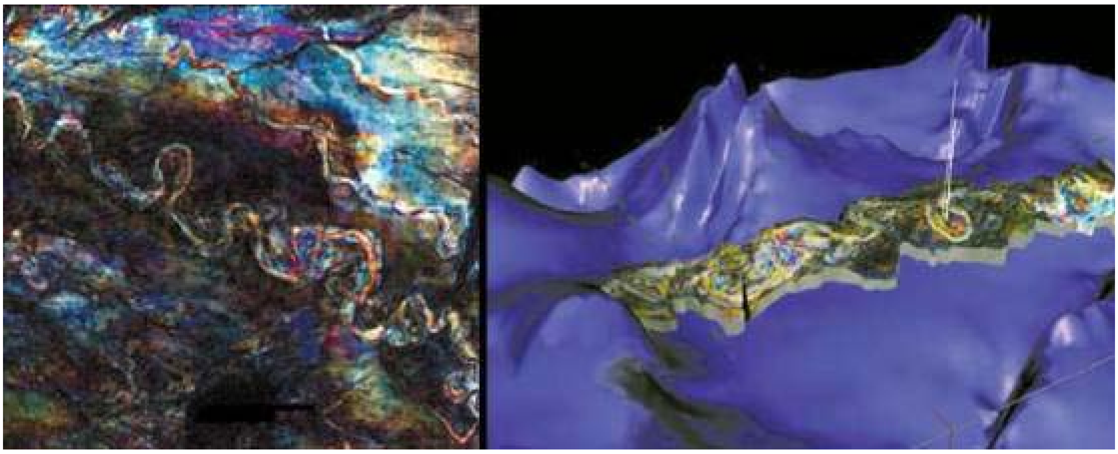
Source: Vitucci, J. (2009, April). Natural Gas Processing and Handling: . *Journal of Petroleum Technology(JPT).* (61), 4, p.64.

APENDIX F

Seismic Imaging Development

3-D Seismic Imaging

One of the biggest breakthroughs in computer-aided exploration was the development of three-dimensional (3-D) seismic imaging. 3-D imaging utilizes seismic field data to generate a three dimensional 'picture' of underground formations and geologic features. This, in essence, allows the geophysicist and geologist to see a clear picture of the composition of the Earth's crust in a particular area. Obviously, this is tremendously useful in allowing for the exploration of petroleum and natural gas, as an actual image could be used to estimate the probability of formations existing in a particular area, and the characteristics of that potential formation. This technology has been extremely successful in raising the success rate of exploration efforts. In fact, using 3-D seismic has been estimated to increase the likelihood of successful reservoir location by 50 percent!



An Example of 3-D Seismic Imaging Technology

Source: BP

Although this technology is very useful, it is also very costly. 3-D seismic imaging can cost anywhere up to $1 million per 50 square mile area. The generation of 3-D images requires data to be collected from several thousand locations, as opposed to 2-D imaging, which only requires several hundred data points. As such, 3-D imaging is a much more involved and prolonged process. Therefore, it is usually used in conjunction with other exploration techniques. For example, a geophysicist may use traditional 2-D modeling and examination of geologic features to determine if there is a probability of the presence of natural gas. Once these basic techniques are used, 3-D seismic imaging may be used only in those areas that have a high probability of containing reservoirs.

In addition to broadly locating petroleum reservoirs, 3-D seismic imaging allows for the more accurate placement of wells to be drilled. This increases the productivity of successful wells, allowing for more petroleum and natural gas to be extracted from the ground. In fact, 3-D seismic can increase the recovery rates of productive wells to 40-50 percent, as opposed to 25-30 percent with traditional 2-D exploration techniques.

3-D seismic imaging has become an extremely important tool in the search for oil and natural gas. By 1980, only 100 3-D seismic imaging tests had been performed. However, by the mid 90's, 200 to 300 3-D seismic surveys were being performed each year. In 1996, in the Gulf of Mexico, one of the largest offshore oil and gas producing areas in the U.S., nearly 80 percent of wells drilled in the gulf were based on 3-D seismic data. In 1993, 75 percent of all onshore exploratory surveys conducted used 3-D seismic imaging.

4-D Seismic Imaging

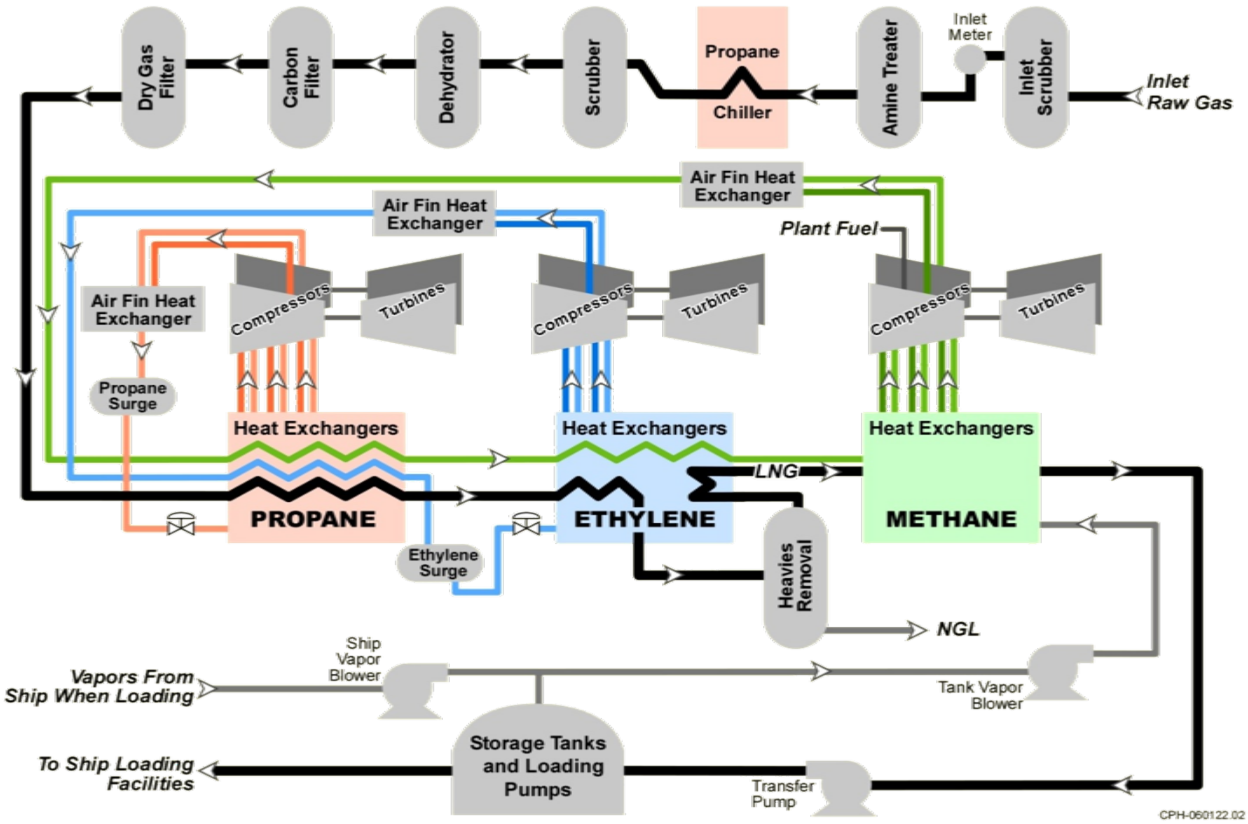
One of the latest breakthroughs in seismic exploration, and the modeling of underground rock formations, has been the introduction of four-dimensional (4-D) seismic imaging. This type of imaging is an extension of 3-D imaging technology. However, instead of achieving a simple, static image of the underground, in 4-D imaging the changes in structures and properties of underground formations are observed over time. Since the fourth dimension in 4-D imaging is time, it is also referred to as 4-D 'time lapse' imaging.

Various seismic readings of a particular area are taken at different times, and this sequence of data is fed into a powerful computer. The different images are amalgamated, to create a sort of 'movie' of what is going on under the ground. Through studying how seismic images change over time, geologists can gain a better understanding of many properties of the rock, including underground fluid flow, viscosity, temperature and saturation. Although very important in the exploration process, 4-D seismic images can also be used by petroleum geologists to evaluate the properties of a reservoir, including how it is expected to deplete once petroleum extraction has begun. Using 4-D imaging on a reservoir can increase recovery rates above what can be achieved using 2-D or 3-D imaging. Where the recovery rates using these two types of images are 25 to 30 percent and 40 to 50 percent respectively, the use of 4-D imaging can result in recover rates of 65 to 70 percent.

Source: Natural Gas - From Wellhead to Burner Tip. (2004). *Natural Gas Supply Association (NGSA)*

APPENDIX G

The Optimized Cascade Process

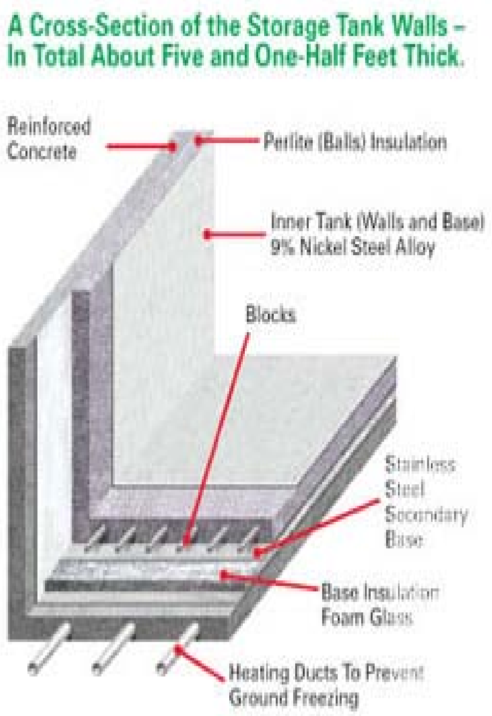


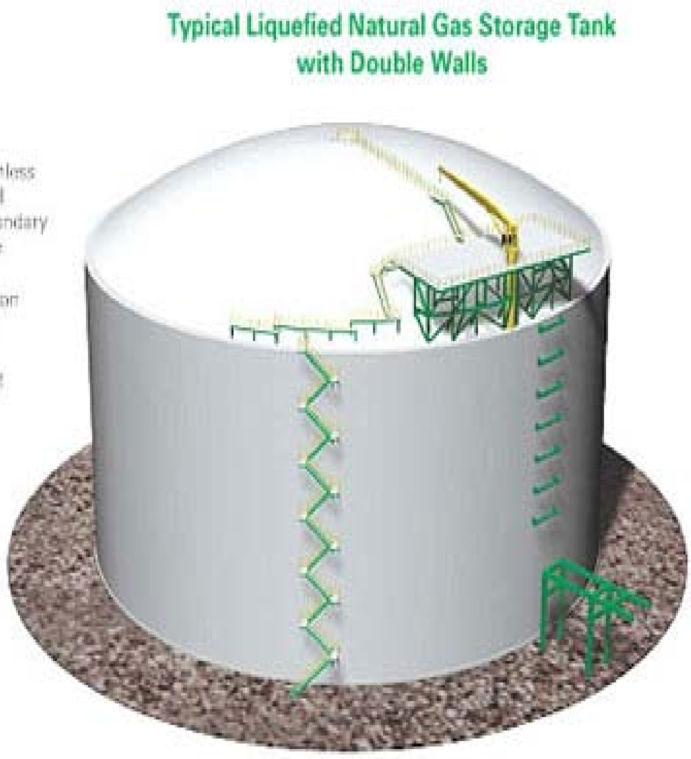
The Optimized Cascade Process is a proven process. Like all liquefaction projects, inlet gas is first treated to remove acid gases, all water and mercury through processes commonly found in gas processing around the world. But the heart of the Optimized Cascade process is three pure refrigerant cycles of propane, ethylene and methane. The gas is then cooled, condensed, subcooled and flashed through these interconnected refrigeration circuits. Each circuit uses turbines to drive compressors to circulate refrigerant, with propane condensed with air cooling, ethylene condensed with propane and methane flash vapors returning to the front end of the plant. In the Optimized Cascade process, typically two, 50% machines are used for each service. This allows continuing operation of the plant when any one compressor is shut down for planned or unplanned maintenance or other upset.

Source: ConocoPhilips. (2007,January). The Darwin LNG Plant Pioneering Aeroderivative Turbines for LNG Refrigeration Service. The Darwin LNG Plant – Pioneering Aeroderivative Turbines for LNG Refrigeration Service

APPENDIX H

The LNG Storage Facility





Source : AES. What is LNG. Retrieved on August 12 2009 from
http://www.aessparrowspointlng.com/aboutlng.asp

APPENDIX I

World Natural Gas Consumption by Region, Reference Case, 1990-2030

(Trillion Cubic Feet)

Region/Country	History 1990	History 2005	History 2006	Projections 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Average Annual Percent Change, 2006-2030
OECD									
OECD North America	**22.5**	**27.1**	**27.2**	**28.4**	**29.4**	**30.8**	**32.8**	**33.3**	**0.8**
United States[a]	19.2	22.0	21.7	22.6	22.8	23.4	24.7	24.4	0.5
Canada	2.4	3.4	3.3	3.4	3.9	4.2	4.5	4.7	1.5
Mexico	0.9	1.8	2.2	2.4	2.8	3.2	3.7	4.2	2.7
OECD Europe	**11.6**	**19.3**	**19.2**	**20.4**	**21.5**	**22.6**	**23.5**	**24.1**	**1.0**
OECD Asia	**2.9**	**5.2**	**5.5**	**5.9**	**6.5**	**6.8**	**6.9**	**7.0**	**1.0**
Japan	2.0	3.1	3.2	3.3	3.6	3.7	3.7	3.7	0.5
South Korea	0.1	1.1	1.1	1.3	1.5	1.6	1.7	1.7	1.8
Australia/New Zealand	0.8	1.1	1.2	1.3	1.4	1.5	1.5	1.6	1.3
Total OECD	**37.0**	**51.7**	**51.9**	**54.7**	**57.4**	**60.3**	**63.3**	**64.3**	**0.9**
Non-OECD									
Non-OECD Europe and Eurasia	**26.7**	**25.3**	**25.4**	**27.5**	**29.9**	**31.3**	**32.1**	**32.8**	**1.1**
Russia	17.3	16.2	16.6	18.0	19.1	19.9	20.3	20.8	0.9
Other	9.5	9.1	8.8	9.6	10.8	11.4	11.8	12.0	1.3
Non-OECD Asia	**2.9**	**9.3**	**9.4**	**11.4**	**15.2**	**18.7**	**21.8**	**24.5**	**4.1**
China	0.5	1.7	2.0	2.6	3.8	4.9	5.9	6.8	5.2
India	0.4	1.3	1.4	1.8	2.4	3.0	3.4	3.7	4.2
Other Non-OECD Asia	2.0	6.4	6.0	7.0	9.0	10.9	12.5	14.1	3.6
Middle East	**3.6**	**9.8**	**10.3**	**11.9**	**13.5**	**14.4**	**15.3**	**16.6**	**2.0**
Africa	**1.4**	**3.0**	**2.9**	**3.4**	**4.3**	**5.1**	**5.8**	**6.2**	**3.2**
Central and South America	**2.0**	**4.4**	**4.5**	**5.5**	**6.3**	**7.0**	**7.7**	**8.1**	**2.4**
Brazil	0.1	0.7	0.7	1.0	1.2	1.4	1.7	1.8	4.1
Other Central and South America	1.9	3.7	3.8	4.5	5.1	5.6	6.0	6.3	2.1
Total Non-OECD	**36.5**	**51.8**	**52.5**	**59.8**	**69.1**	**76.5**	**82.7**	**88.2**	**2.2**
Total World	**73.5**	**103.4**	**104.4**	**114.4**	**126.5**	**136.8**	**146.0**	**152.5**	**1.6**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.

Source: History: EIA, International Energy Annual 2006 (June –December). Projections: Annual Energy Outlook 2009. DOE/EIA-0383(2009),Washigton, DC, March, 2009.

APPENDIX J

Current LNG supply Projects by Basin and Country in MMtpa (Bcf/day)

Liquefaction Project	2007	2008
Atlantic Basin		
Algeria	19.6 (2.5)	18.6 (2.4)
Egypt	11.9 (1.5)	12.1 (1.6)
Equatorial Guinea	1.8 (0.2)	3.2 (0.4)
Libya	0.9 (0.1)	0.9 (0.1)
Nigeria	18.3 (2.4)	20.1 (2.6)
Norway	1.0 (0.1)	4.2 (0.5)
Trinidad	14.8 (1.9)	16.4 (2.1)
Subtotal, Atlantic Basin	*68.3 (8.7)*	*75.5 (9.7)*
Middle East		
Abu Dhabi	5.9 (0.8)	5.9 (0.8)
Oman	10.4 (1.3)	10.7 (1.4)
Qatar	28.1 (3.6)	29.9 (3.8)
Subtotal, Middle East	*44.4 (5.7)*	*46.5 (6.0)*
Pacific Basin		
Australia	15.2 (2.0)	15.4 (2.0)
Brunei	7.2 (0.9)	7.2 (0.9)
Indonesia	21.3 (2.7)	19.3 (2.5)
Malaysia	23.4 (3.0)	23.7 (3.0)
U.S.A.	1.4 (0.2)	1.3 (0.2)
Subtotal, Pacific Basin	*68.5 (8.8)*	*66.9 (8.6)*
Total, All Basins	***181.2 (23.2)***	***188.9 (24.3)***

Note: Existing plant capacity is based on design capacity plus any de-bottlenecking or expansions carried out at the plants.

Source : Reported Benjamin Schlesinger and Associates by American Gas Foundation from Poten & Partners, Inc 2008.

Appendix K

Potential Additional LNG Projects

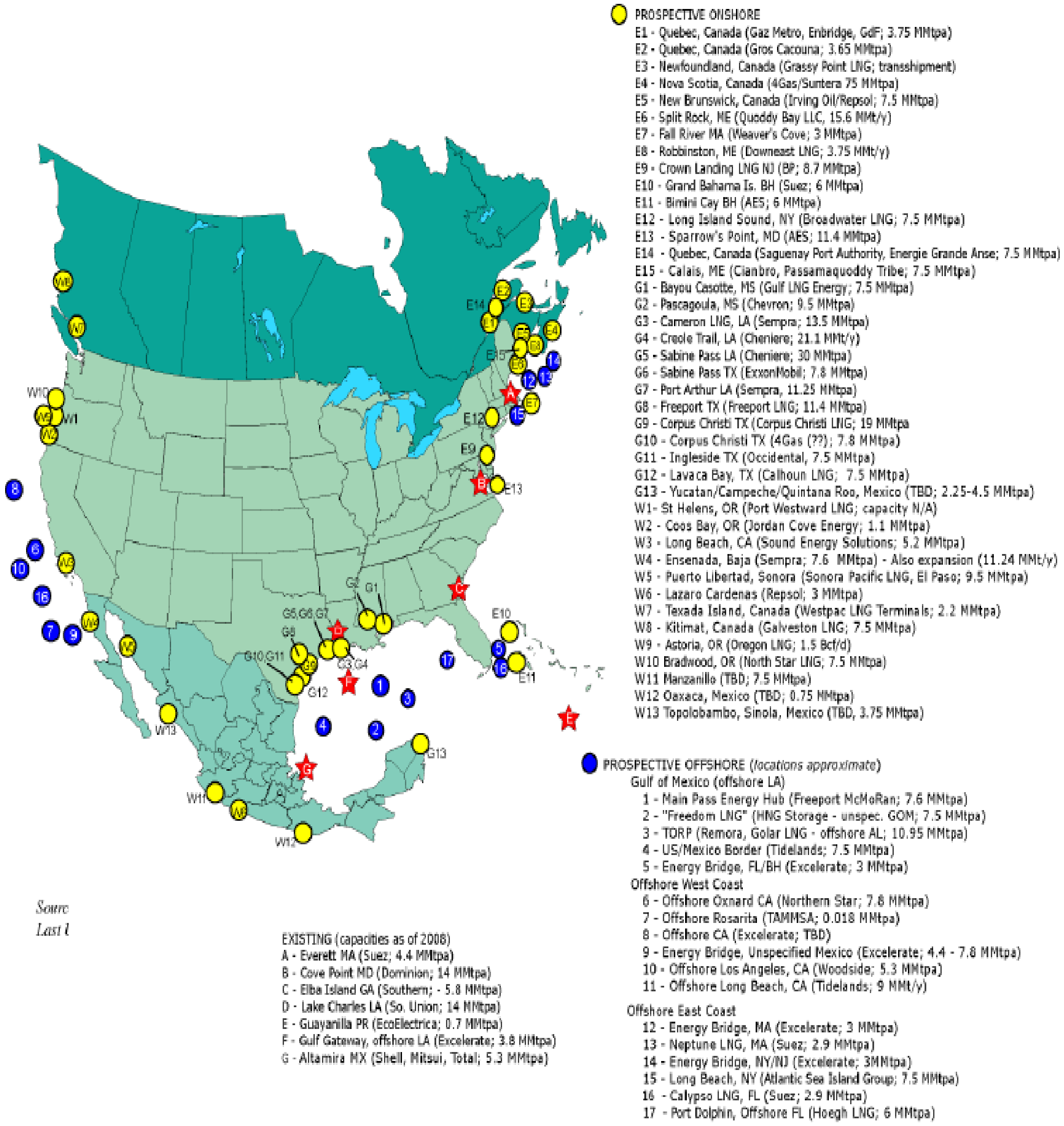
Country, Plant Name	Expected Start Date	Nameplate Capacity, MMt/y (Bcf/day)
Atlantic Basin		
Egypt – Segas	**2013**	**5.0 (0.6)**
Egyptian LNG	**2014**	**3.6 (0.5)**
Equatorial Guinea	**2015**	**4.4 (0.6)**
Algeria – Gassi Touil	**2015**	**4.0 (0.5)**
Trinidad – Atlantic LNG	**2016**	**5.2 (0.7)**
Russia – Shtockman	**2017**	**10.0 (1.3)**
Algeria – Gassi Touil	**2017**	**4.0 (0.5)**
Lybia	**2017**	**3.2 (0.4)**
Norway – Snohvit	**2018**	**4.3 (0.6)**
Angola LNG	**2018**	**5.0 (0.6)**
Venezuela LNG	**2020+**	**4.7 (0.6)**
Subtotal, Atlantic Basin		***53.4 (6.9)***
Middle East		
Iran – Pars LNG	*	**5.0 (0.6)**
Iran – Persian LNG	*	**8.5 (1.1)**
Iran – Pars LNG	*	**5.0 (0.6)**
Iran – Persian LNG	*	**8.6 (1.1)**
* Iran – Qatar (post moratorium)	**2016**	
Int'l oil company sponsors of proposed Iranian LNG projects have delayed development of Pars & Persian projects		
Subtotal, Middle East		***27.1 (3.4)***
Pacific Basin		
Russia – Sakhalin LNG	**2013**	**4.8 (0.6)**
Indonesia – Tangguh LNG	**2013**	**3.5 (0.5)**
Australia – Sunrise LNG	**2014**	**5.3 (0.7)**
Australia – Ichthys LNG	**2016**	**6.0 (0.8)**
Papua New Guinea	**2017**	**5.0 (0.6)**
Australia – Gorgon LNG	**2018-2020**	**10.0 (1.3)**
Australia – Ichthys LNG	**2020**	**6.0 (0.8)**
Subtotal, Pacific Basin		***40.6 (5.2)***
Total, All Basins		***126.1 (16.1)***

Note: Re Advanced Planning and Potential, project sequence and suggested start-up dates are based on Poten's assessment of Front End Engineering and Design contracts (FEED); Final Investment Decision (FID) by the project sponsors, signed EPC contracts, gas resource availability; strength of project participants; sponsor announced plans, and expansion prospe of existing plants. Judgments are also informed by assessment of EPC contractor resource availability compared to the LNG plant construction backlog. Poten also estimates the Cost of Service based on proprietary calculations to determine the cost ($/MMBtu) to produce LNG and supply projected markets, considering LNG demand.

Source: Reported Benjamin Schlesinger and Associates by American Gas Foundationfrom Poten & Partners, Inc 2008.

APPENDIX L

North American LNG Import Terminals



Source: Reported Benjamin Schlesinger and Associates by American Gas Foundation from Poten & Partners, Inc 2008.

APPENDIX M

Conversion Tables

Frequently Used Conversions

To: / From:	Billion Cubic Meters NG	Billion Cubic Feet NG	Million Tons LNG	Trillion Btu
	MULTIPLY BY			
1 Billion Cubic Meters NG	1	35.3	0.73	38.8
1 Billion Cubic Feet NG	0.028	1	0.021	1.1
1 Million Tons LNG	1.38	48.7	1	51.9
1 Trillion Btu	0.028	0.98	0.02	1

One-to-One Conversion Table

To:	Liquid Measures			Vapor Measures		Heat Measure
From:	Metric Ton LNG	Cubic Meter LNG	Cubic Foot LNG	Cubic Meter Natural Gas	Cubic Foot Natural Gas	Btu*
Metric Ton LNG	1.00	2.19	77.47	1,335.90	47,256.70	51,982,370
Cubic Meter LNG	0.46	1.00	35.3	610.00	21,533.00	23,686,300
Cubic Foot LNG	0.012	0.028	1.00	17.08	610.00	671,000
Cubic Meter Natural Gas	0.000749	0.001639	0.058548	1.00	35.30	38,830
Cubic Foot Natural Gas	0.000021	0.000046	0.001639	0.03	1.00	1,100

*Based on Volume Conversion of 610:1 and 1,100 gross dry Btu per cubic feet of vapor.