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The future of LNG in Europe and the potential impact on the market power of the gas suppliers

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1. Preface

During my years of studying I have increasingly become interested in the energy sector and its mechanisms. This interest has been strengthened by working in the energy sector, both in Schlumberger and in Statkraft AS, and by taking the course "Petroleum Economics" in the fall 2005.

In Europe, natural gas has traditionally been imported mainly by pipelines from Russia, Norway and to some extent from Algeria. The market for gas supplies to Europe has been stable and characterized by long-term agreements and bilateral political considerations. The imports have come in addition to substantial indigenous production. Recently, indigenous production has been falling, and together with increased consumption this has led to a supply gap. This supply gap and increased demand for flexibility have in turn given new actuality to the concept of liquefying the gas and transporting it as LNG. A major motivation for this paper is to analyze and discuss to what extent LNG will contribute to the European energy balance the coming decades.

If LNG gains a significant role in the European energy balance, how will the current large suppliers be affected? Will the introduction of new gas suppliers alter the market power of the current suppliers? This market power has not been challenged by new entrants until now. Will increased use of LNG lead to increased competition between rivalling exporting countries, thus creating a freer market? Or may the new entrants have more incentives to collude, and create a cartel?

I believe that predicting the future of LNG and understanding its potential impact on the market power of the current suppliers of gas to Europe is essential in order to predict and understand the energy market in Europe in the coming years. This is due to the important role natural gas is expected to play in power generation and because of the flexibility LNG offers.

Thus, my research question becomes: "What is the future role of LNG in Europe and will increased use of LNG change the market power of the current gas suppliers?"

I have sought to answer this question by applying theoretical models, interviewing analysts and studying literature on the subject. This approach has enabled me to view the LNG-market from several angles and gain valuable insight into the dynamics and challenges in this market. Gathering exact information has been a challenge because of high degree of secrecy concerning prices and investments.

I would like to thank my advisor and lecturer in Petroleum Economics, Røgnvaldur Hannesson, for his valuable feedback and inspiring lectures. I would also like to thank analysts and others who have provided input, especially Emmanuel Soetaert at Statkraft, Bjørn Brochmann at Pointcarbon and Lars-Ivar Berge at NHH.

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2. Executive summary

Natural gas is today one of the fastest growing energy sources in the world. This is due to the fact that it is very convenient as it can be used by households directly, as fuel in engines or as fuel in flexible power generation. Moreover, higher energy prices and the focus on reducing CO_2 emissions have made natural gas more attractive as a substitute for oil and coal.

The driving forces for renewed interest in natural gas and LNG:

- Increased demand for combined cycle power generation in order to meet growing electricity consumption.
- Technological advances lead to cost reductions which make previously uneconomic LNG supply chains profitable.
- Environmental concerns makes natural gas more attractive because CO_2 prices rise.
- LNG is a means for diversification as security of energy supply is becoming increasingly important.

Europe produces substantial amounts of natural gas, but its production is declining. This makes Europe even more dependent on imports from the two regions with the largest reserves, the Middle East and Russia. Natural gas consumption in Europe is predicted to increase strongly the next decades. The increasing demand in Europe stems from the benefits of using natural gas in power generation and directly in households. Gas fired power plants emit less CO_2 and are more flexible than the traditional coal power plants. There are currently three regional markets for gas, Europe, North America and East Asia.

Natural gas can be transported either through pipelines or in liquid form on vessels, as LNG. LNG has become more popular in recent years because of its flexibility and the lack of exploitable gas reserves close to Europe. Furthermore, costs in the LNG value chain have decreased due to technological advances.

LNG prices are closely linked to the price of fuel oil in the long-term, rigid contracts that characterize the market. Recently, LNG contracts have started to be of shorter duration and a small short-term market that is close to being a spot market has developed.

Security of supply is high on the agenda in Europe because of the increasing import dependency and the large market shares of especially Russia, and increasingly Algeria. LNG is supposed to play a significant role in improving security of supply through diversification. Countries like Qatar, Oman, Nigeria and Trinidad and Tobago are set to become significant exporters to the European market.

Importers in Europe seem committed to increasing LNG-imports as they are making substantial investments in reception capacity. A condition for increased use of LNG in Europe is that Europe is able to compete with the other gas markets in attracting new supplies. Europe has a cost advantage over North America and East Asia when it comes to supplies from Africa and the Middle East, but the US will still be a serious competitor because of its strong gas demand and political and financial power.

Russia, Norway and Algeria are characterized by selling most of their gas through large partly- or fully state-owned companies. The companies, Gazprom, Sonatrach and StatoilHydro, have very substantial power over the gas exports from their respective countries.

Russia, Algeria and Norway do not engage in formal price coordination and there is little evidence that they have coordinated policies. However, it is clear that they do enjoy some oligopoly power and that especially Russia is in the position of exploiting this power.

The lessons learned from the OPEC cartel in the oil market, show that cartelization in a market with inelastic supply and demand may be very profitable if a significant part of the producers join and the internal discipline is strong. The history of OPEC also shows that in the long term substitution will lead to loss of power if cartels drive prices to high.

Increased use of LNG may reduce the oligopoly power of the current suppliers by increased flexibility in choosing supplier and especially by reducing the current suppliers' market share if significant volumes of gas are being imported as LNG. However, increased use of LNG may lead to more market power in the hands of the suppliers. There is a possibility that the LNG exporters may organize a cartel much like the OPEC cartel, but with a larger part of total output in the cartel. Because there are substitutes to gas both in the short-term and in the long-term, a gas cartel will probably be relatively short-lived, although being able to control prices for some time.

3. Introduction

In this thesis I will seek to answer my research question which is "What is the future role of LNG in Europe and will increased use of LNG change the market power of the current gas suppliers?" I will start by providing a background for the discussion. I will briefly cover the basics of natural gas, the basics of LNG, and natural gas and LNG in Europe specifically. These parts will be the basis for discussing the research question.

In order to analyze the future of LNG in Europe I will structure the discussion as follows: First, there will have to be demand for LNG. This will have to come from increased demand for natural gas, as LNG only is a way to transport natural gas. Natural gas will need to be attractive compared to other energy sources. Furthermore, some part of the increased gas volumes must be transported as LNG instead of by pipelines. Finally, Europe must offer sufficient reception capacity for LNG.

Second, there will have to be supply of LNG. New gas fields must be developed in places where LNG transportation is superior to pipeline transportation. LNG may be superior to pipelines for economic reasons or for reasons of security of supply. Furthermore, a certain part of the new LNG supplies will have to be destined for Europe. Europe must be able to compete with North America and the industrialized countries of East Asia in order for LNG to gain increased importance in Europe.

In the last part of the thesis I will analyze the potential impact of LNG on the market power of the suppliers of gas to the European market. In order to do this I will first consider the current characteristics of the supplies from Russia, Algeria and Norway. I will relate the situation to theory of oligopoly power and use OPEC as an example of cartelization in the energy market. I will continue by discussing whether these countries have and use market power when supplying Europe with gas, and if potential new suppliers may gain market power. To gain insight into this matter I will study literature on the subject and interview analysts.

In order to limit this paper I will not treat the internal workings of the European gas market, including regulation and company structure. I will neither include peripheral subjects such as the LNG shipping market and the Kyoto protocol. When subjects like these influence the discussion I will make commonly accepted assumptions.

I would like to emphasize some of the key assumptions I have made in this paper.

Firstly, in this paper I define Europe as being Western Europe, i.e. EU15 and Switzerland. On some occasions and in some statistics I may deviate from this definition, but only when deviations are of insignificant importance for the result. Norway will not be treated as a part of Europe in most contexts.

Secondly, I will treat LNG only, and not include LPG[1] or NGL[2].

Finally, when analyzing the potential development of the market power of the suppliers, I will look at the supplying countries, not companies. As most gas exporting companies are state-owned these approaches will mainly coincide.

A list of abbreviations is to be found in appendix 11.1.

[1] Liquid Pressurized Gas
[2] Natural Gas Liquids

4. Basics of natural gas

In order to be able to analyze the research question it is necessary with an overview of natural gas. Important topics to be covered include production, consumption and total reserves. Furthermore, the two main transportation modes and a brief overview of gas prices are presented.

4.1. Definitions and chemical composition

Natural gas is the product of what was once organic material. After millions of years in high temperatures and under very high pressure, this material has been transformed into fossil fuels like coal, oil and natural gas. The deeper underground one drills, the more natural gas relative to oil one finds, and in the deepest wells one can find pure natural gas.[3]

Natural gas is a colourless and odourless gas of hydrocarbons where methane is the primary component. It usually contains other gases as well, where ethane, propane, butane, pentane and hexane are the most common.

Natural gas is classified as "wet" or "dry" depending on the level of liquid components at atmospheric pressure. Wet gas contains mainly ethane, propane and butane. The last two are components of crude oil and called LPG (Liquefied Petroleum Gas). Wet gas is often sold as Natural Gas Liquids (NGL). Dry gas consists almost exclusively of methane, and does not contain any liquid components. This gas is either transported through pipelines or stored in tanks. When stored and transported in tanks, the gas is either compressed (CNG)[4] or liquefied (LNG).[5]

While crude oil is mainly measured in barrels, the volume of natural gas is measured in a number of ways, e.g. cubic feet, tons, oil equivalents and cubic meters. In this paper I will mainly use cubic meters.

[3] Naturalgas.org
[4] Compressed Natural Gas
[5] NVE (2004)

4.2. Reserves and production

Natural gas is often found together with oil in deep oil wells. There are also pure gas fields that only produce natural gas. Where oil and gas are found together, the gas is separated from the oil and taken to the processing plant. There, the gas is “dried” i.e. the dry gas is separated from the wet gas and other components. The different products are then transported by pipeline or ship to the receiving terminals, from where it is distributed to the end users.

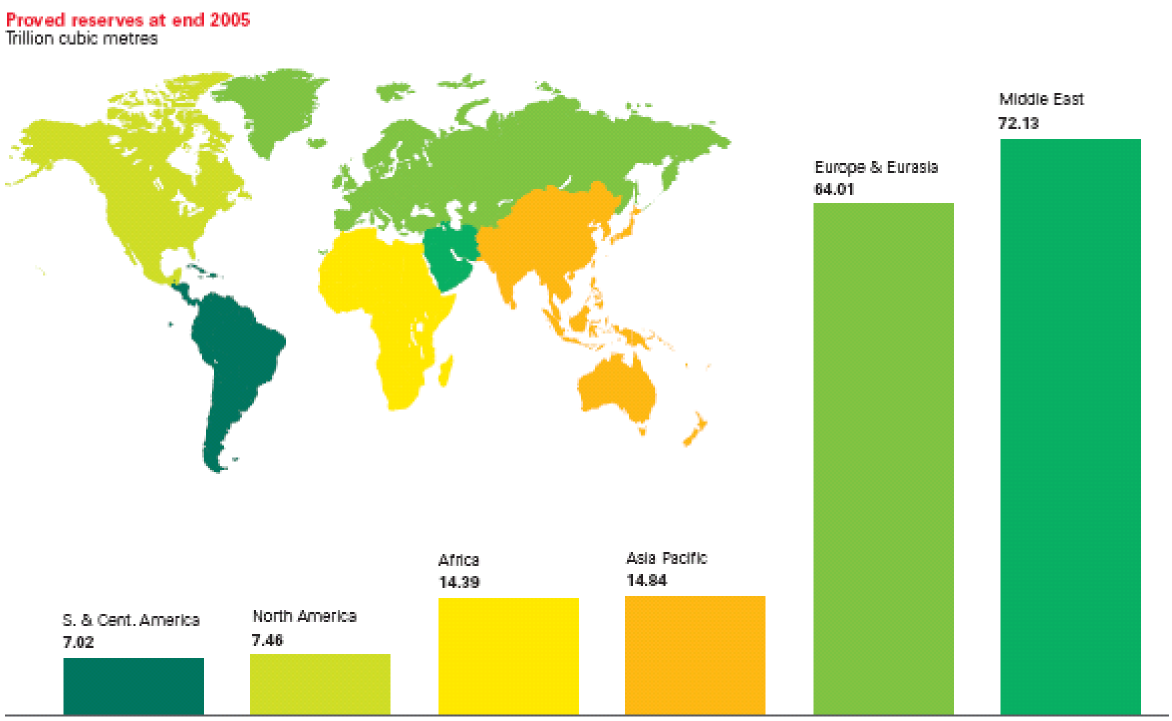
The supply of gas is determined by several factors. The price the producer expects to get in the market is clearly important when deciding whether to invest in gas extraction or not. Price expectations also affect the level of exploration and research. Then there are technological barriers which make some discovered fields uneconomic. As the reserves of natural gas are finite, there will be increasingly less gas left. The gas which is easiest to extract will be extracted first, which means that new production capacity will be more expensive than the current. However, the total amount of gas in the world is not known, and new discoveries of gas fields which are uncomplicated to develop may increase supply.

Natural gas is found and produced in many parts of the world, but the reserves are very unevenly spread across the globe. As can be seen below, Russia and the Middle East hold most of the world’s known reserves. It is worth noticing that these numbers are proved reserves. In many Middle East countries natural gas has until now been regarded as merely a bi-product of oil and these countries have not explored their reserves extensively. The European and North American countries have explored their territories thoroughly as their R/P-ratio has declined. This may imply that the reserves of the Middle East countries and Russia may be even greater relative to those of Europe and North America than showed in the table below.

Reserves and R/P-ratios			
Country	Tcm	Share of total	R/P-ratio
Russia	47.82	26.6%	80.0
Iran	26.74	14.9%	Over 100
Qatar	25.78	14.3%	Over 100
Saudi Arabia	6.90	3.8%	99.3
UAE	6.04	3.4%	Over 100
USA	5.45	3.0%	10.4
Nigeria	5.23	2.9%	Over 100
Algeria	4.58	2.5%	52.2
-	-	-	-
EU25	2.57	1.4%	12.9
Norway	2.41	1.3%	28.3

(BP statistical review of world energy 2006)

As seen in the table above, Europe holds very modest reserves compared to total world reserves. It is worth noticing that Norway holds close to half of European reserves. Russia has over one-quarter of total world reserves, which shows how important Russia is as a natural gas supplier. The Middle East has 72.13 Tcm (40.1%) and Africa has 14.39 Tcm (8.0%) of total world reserves.



When looking at the main producers of natural gas, one finds that these are not necessarily the same as those with the largest reserves. Russia and USA are by far the largest producers, although the American production is decreasing relatively rapidly.

Production		
Country	bcm/ year	Share of total
Russia	598.0	21.6%
USA	525.7	19.0%
Canada	185.5	6.7%
UK	88.0	3.2%
Algeria	87.8	3.2%
Iran	87.0	3.1%
Norway	85.0	3.1%
-	-	-
Netherlands	62.9	2.3%
EU25	199.7	7.2%

(BP statistical review of world energy 2006)

4.3. Consumption

Natural gas is very flexible in its use, and can be used directly for heating and cooking, or in engines, fuel cells or power generation. One can distinguish between gas use in households, power generation, and industrial use. Households use gas from pipes or containers as a substitute for electricity in cooking and heating. Using natural gas in power generation has been increasingly widespread as it emits far less CO_2 and toxic gases than oil and in particular coal. A gas power plant emits approximately half of the CO_2 that a coal fired plant emits. Gas fired power stations also have the advantage of being flexible regarding output, and are thus suited for producing peak load, which means they can charge higher prices than base load producers. Natural gas is also used directly as fuel in cars, buses and boats. Natural gas is an important raw material in production of certain chemicals and fertilizers.

The use of gas varies widely between countries. As can be seen from the table below, USA is by far the largest consumer of natural gas today. The European countries consume large amounts as well and far more than they produce.

Consumption		
Country	bcm	Share of total
USA	633.5	23.0%
Russia	405.1	14.7%
UK	94.6	3.4%
Canada	91.4	3.3%
Iran	88.5	3.2%
Germany	85.9	3.1%
Japan	81.1	2.9%
Italy	79.9	2.9%
-	-	-
EU25	471.2	17.1%

4.4. Modes of transportation

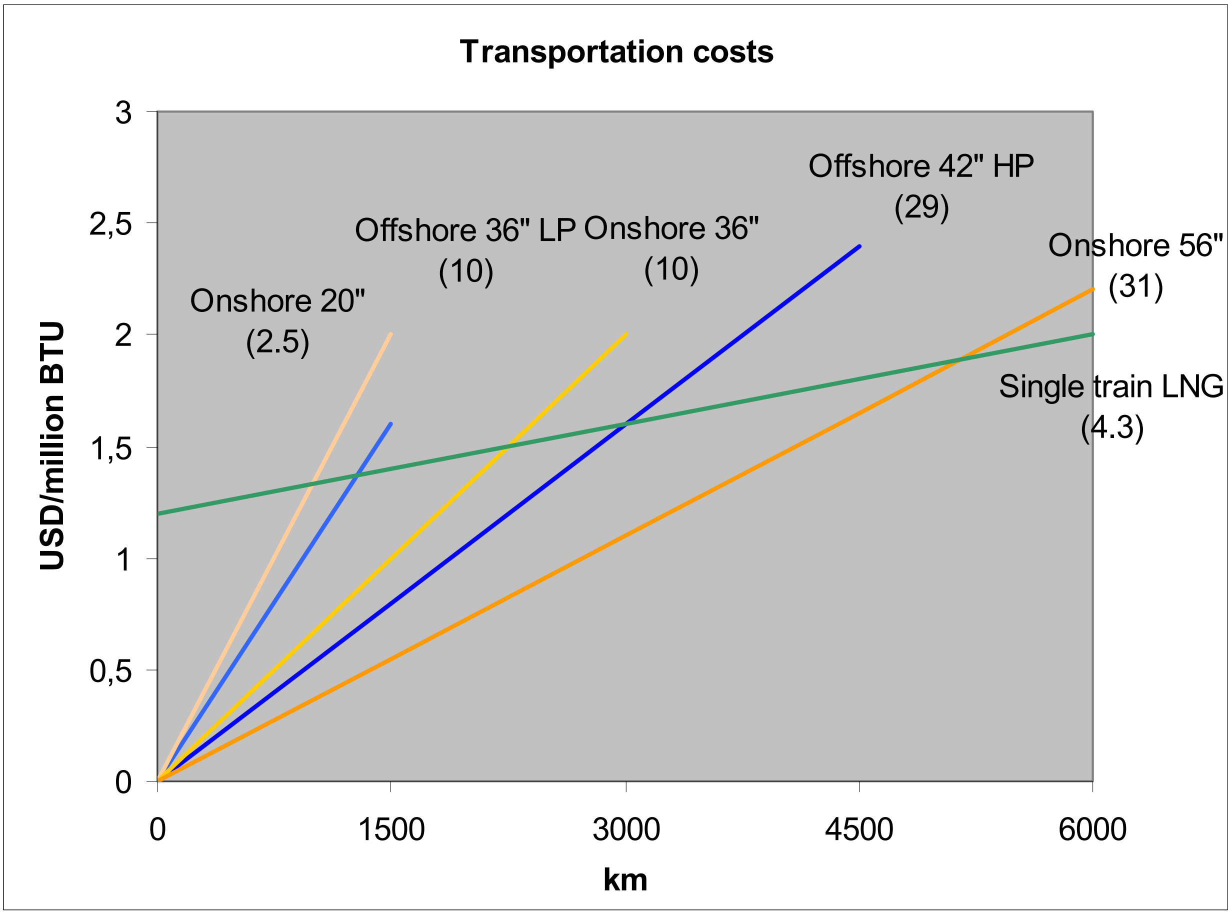
Transporting large amounts of gas over long distances can be done in two ways, either by pipelines or in liquefied form by ship. Both solutions are very capital intensive and require a large and stable production to be economically feasible.

When constructing a pipeline, total costs will grow almost linearly with distance and there will be small fixed costs that are not related to distance. The major cost component of a pipeline project is the pipeline itself. While there are no economies of scale with respect to distance, there are substantial economic benefits from constructing pipeline with larger diameter. The total costs of constructing a 20" pipeline and a 40" pipeline are relatively similar, but the latter will have far less costs per unit of transportation capacity as it may transport four times as much.[6] Offshore pipelines are generally more expensive than onshore pipelines.

In LNG, the main cost component is the liquefaction. The shipping operation accounts for between 30 and 40 percent of total transportation costs, while the remaining are fixed capital costs related to liquefaction and regasification. LNG transportation costs will increase with distance, but not as much as pipeline costs. The reason for this is that when the distance increases the fixed costs of liquefaction and regasification are spread over more kilometres.

The result is that pipeline is more favourable than LNG on shorter distances while LNG is superior to pipelines for longer distances.

[6] A doubling of the diametre will give a fourfold capacity increase because the capacity is given by the area of the cross-section which in turn is given by the formula $A=\pi * r^2$



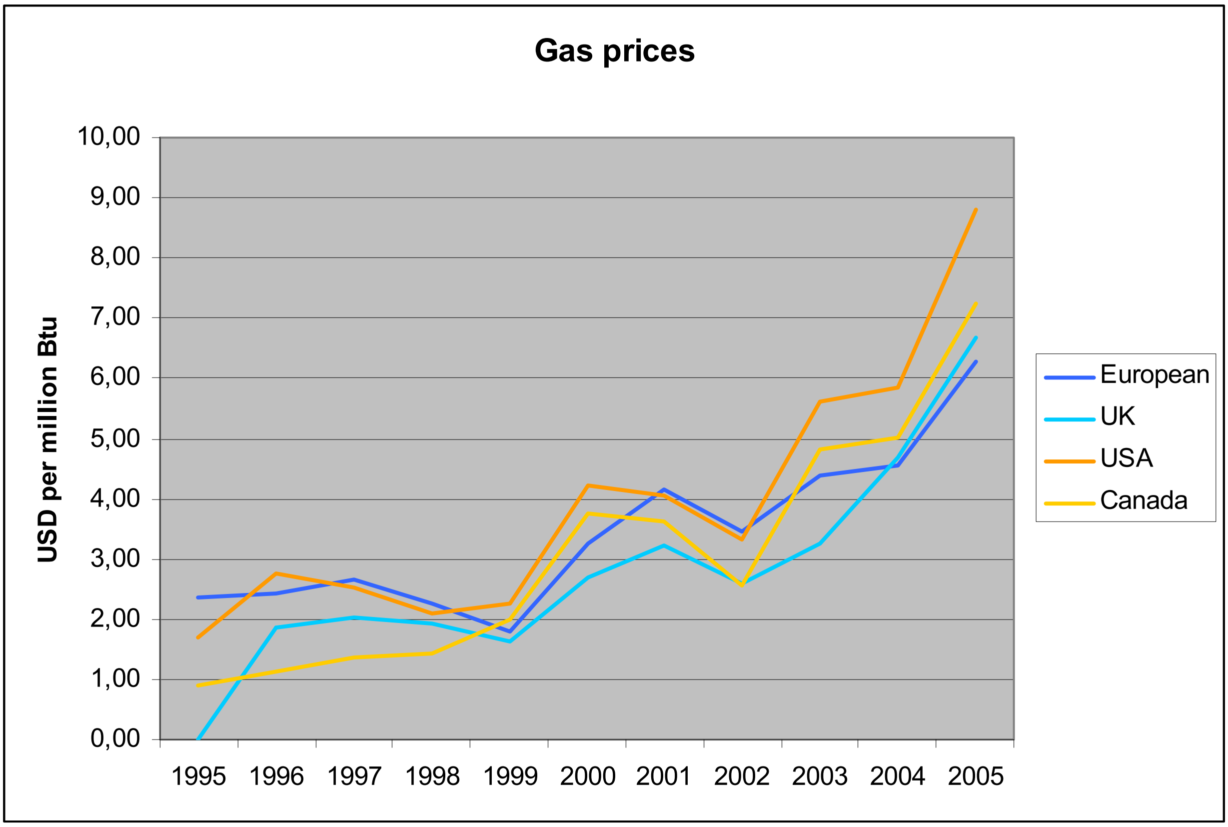
The figure shows the transportation costs for different modes of transportation for different distances. LP means Low Pressure and HP means High Pressure. The number in brackets is the amount of gas in bcm that is delivered per year. It is important to notice that the volume carried by LNG is much smaller than the volume carried by most of the pipelines in this figure.

Approximate distances (by sea) presented for illustration:
Arzev (Algeria) – Barcelona (Spain): 450km
Skikda (Algeria) – Rome (Italy): 600km
Qatar – Barcelona (Spain): 7400km
Troll (Norway) – Zeebrugge (Belgium): 800km
Arzev (Algeria) – London (UK): 2250km

4.5. Pricing

Natural gas competes with fuels such as coal, oil and nuclear power. In the longer term, natural gas may be substituted by these fuels in electricity generation, and the electricity may substitute household consumption of gas. In the medium term power plants can switch between oil, gas and coal. This makes the gas price dependent on the price of other fossil fuels.

In practice most gas is sold in fixed contracts with the price being formally linked to the price of fuel oil / light heating oil. Therefore, the gas price is especially tightly linked to the oil price. Still it varies between regions and countries, although the trends are the same, as can be seen in the figure below.



(Based on price series from BP Statistical Review 2006)

Until 2002, European and American gas prices followed each other. From 2002 the price differential increased as American prices soared more than European. Although not shown in the figure, prices have converged the last two years.

5. Basics of LNG

This chapter will treat LNG specifically, and analyze the different parts of the LNG value chain and the cost structure of the value chain. This will be an important basis for the analysis of investments in LNG. This chapter will also include an overview of the market structure and market mechanisms.

5.1. Technical specifications and concept

At -162 degrees Celsius at atmospheric pressure, natural gas (methane) will condensate and become an odourless, clear, non-toxic and non-corrosive liquid. It is then 600 times more compressed than it is in gas form.[7] Because of this reduction in volume, liquid gas can be transported in tanks at a competitive cost. Shipping LNG by sea is the only viable way to transport the natural gas over distances and areas where pipeline transport is impossible. LNG is also used for flexibility purposes in connection with pipelines, so-called peak-shaving facilities. In these facilities some of the gas is liquefied and stored, in order to be able to supply more than the production when demand is particularly high.

In the early stages of the LNG development there were concerns over the potential hazards of transporting large amounts of explosive gas. However, methane is lighter than air and burns only when the concentration is 5% – 15% of air. Because of this, the gas will be dispersed into the atmosphere in the event of leakage, and the probability of an explosion is rather low. There have not been any serious accidents, partly due to the very strict safety regulations. There have been only two groundings, one collision and one breakdown involving LNG-vessels, none of them causing pollution.

5.2. Value chain

When the natural gas has been extracted from the well, the gas is taken to a reception terminal by pipeline, either offshore or onshore. From there it is either distributed by pipeline, using powerful compressors, or liquefied. I will now examine the LNG value chain from the liquefaction process to the pipelines of the importing country.

[7] BP.com (2006)

5.2.1. The liquefaction process

The liquefaction process takes place in a condensation plant where the natural gas is cooled to approximately -162°C. The wet gas is first treated in order to remove water and other substances like mercury and carbon dioxide. Next, the gas is cooled to -35°C to separate the heavier hydrogen atoms from the methane. This step is not done for pipeline gas, making LNG "cleaner", i.e. with higher methane content than pipeline gas. Finally, the gas is cooled to -162°C. There are two main technologies used in liquefaction today, namely Air Products (APCI) and the Phillips cascade technology.[8]

The liquefaction process requires large amounts of energy, and between 5 and 15% of the gas is used in the plant during the cooling process.[9] Liquefaction is done in what is called "trains", which are relatively separate production units. One train usually produces approximately 3 mtpa (Million Tons Per Annum) of LNG.[10] Until recently, trains with a capacity of 4 mtpa have been considered very large, but recently several trains of this size and larger have been designed. (Bechtel) In March 2004 the largest train in the world was train nr 4 in Port Fortin, Trinidad, with a capacity of 5.2 mtpa.[11] However, the size of trains is assumed to increase in the near future. Conoco Phillips and Bechtel Corporation believe that 8 mtpa trains are both technically and economically feasible.

5.2.2. LNG-shipping

LNG is mainly transported using specialized vessels which are purpose built for carrying LNG. The double hull vessels are fitted with 4-7 large insulated tanks which are constructed so that the loss of gas because of vaporisation is limited. Some loss by vaporisation will occur, but usually this is used as fuel for the ship. The vessels are complex and expensive structures compared to oil tankers, especially because of the LNG tanks and strict safety regulations. Earlier LNG vessels were produced mainly in western European yards because of the complexity involved, but today low cost producers such as South Korea have captured a significant market share and the entry of South Korea and possibly other low-cost producers lowers new-building prices.

[8] Weems (2000)
[9] NVE (2004)
[10] Bechtel (2007)
[11] Bechtel (2007)

From the early start of LNG shipping the size of the ships has increased and the most widely used ships now carry 130,000 cubic meters. Vessels with a capacity of 265,000 cubic meters are currently under construction.[12] This increase in size facilitates the realisation of economies of scale, but at the same time limits the vessels to certain trades with large ports, high volumes and/or large storage facilities. Due to vaporization and the high capital costs, the speed of LNG-vessels is high compared to ordinary vessels with a speed of 20knots. Loading and unloading are also fast, taking around 12 – 18 hours.

The LNG fleet is currently made up by 179 vessels worldwide; with a total capacity of 25.1mcm.[13] Due to the rapid expansion of LNG facilities, there were 130 vessels under construction or in the order book by the end of 2005, and Drewry Shipping expects the number of LNG carriers to surpass 400 in 2011 or 2012.[14] An important aspect of the economics of shipping is the supply lag of new-buildings. The delivery time for an LNG vessel varies with the general shipping cycles and thus the capacity at the yards.

An arrangement where the shipper owns the ship himself has been common in LNG shipping because of an almost non-existent spot market and high investment costs. Lately, several pure shipping companies like Golar LNG and Bergesen have been investing in LNG carriers and renting them out on time charter.

In some cases the LNG seller takes responsibility for the cargo until it is unloaded at the reception terminal, while in other cases it is sold as a so-called FOB which means Free on Board. The latter means that the gas is sold when it moves from the liquefaction plant to the ship. This is becoming increasingly popular among buyers.

[12] QMax LNG carriers ordered from South Korean yards for use in export from Qatar. Source: EIA
[13] EIA (2006) and Shell (2007)
[14] Shipping Economics, Lecture Notes

5.2.3. Regasification and storage

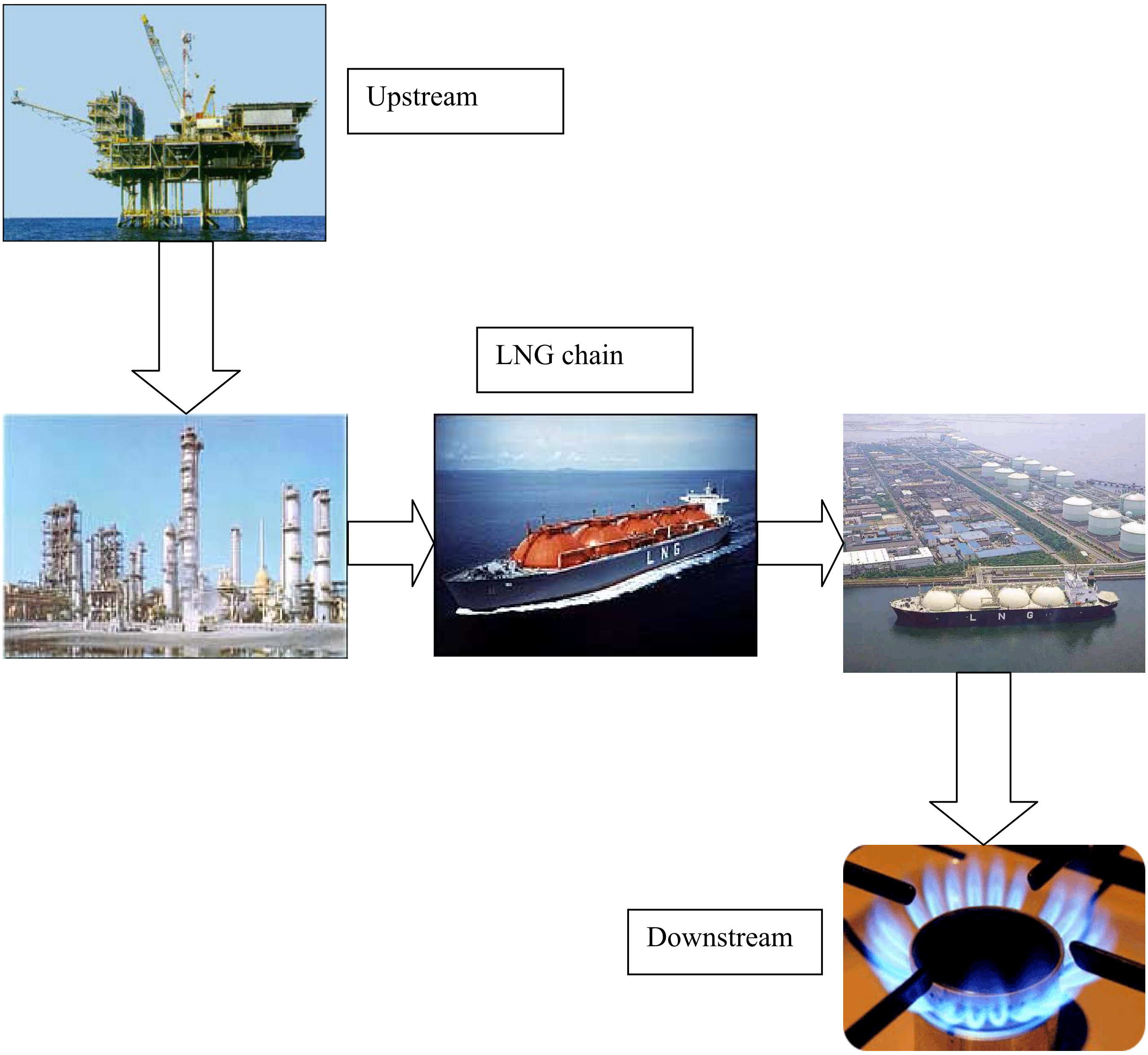
In the regasification plant the liquid gas is heated and made gaseous again. There are several technologies used for this purpose, the most usual being direct-fired heaters and heating by passing the gas through pipes submerged in seawater or heated water. This process requires energy, but significantly less than for liquefaction. Large compressors are used to pump the gas into the pipelines.

The plant contains storage facilities with insulated tanks where the LNG is stored in order to be able to distribute the gas smoothly on to the consumers. The storage capacity varies significantly between regasification plants and this capacity is a main cost driver for a reception terminal. Sometimes ships are used for storage as well.

Storage capacity is vital in order to be able to cover peak demand and/or minor disruptions in deliveries. However, there will typically be storage facilities further on in the distribution chain, like depleted reservoirs in connection with the pipeline system.

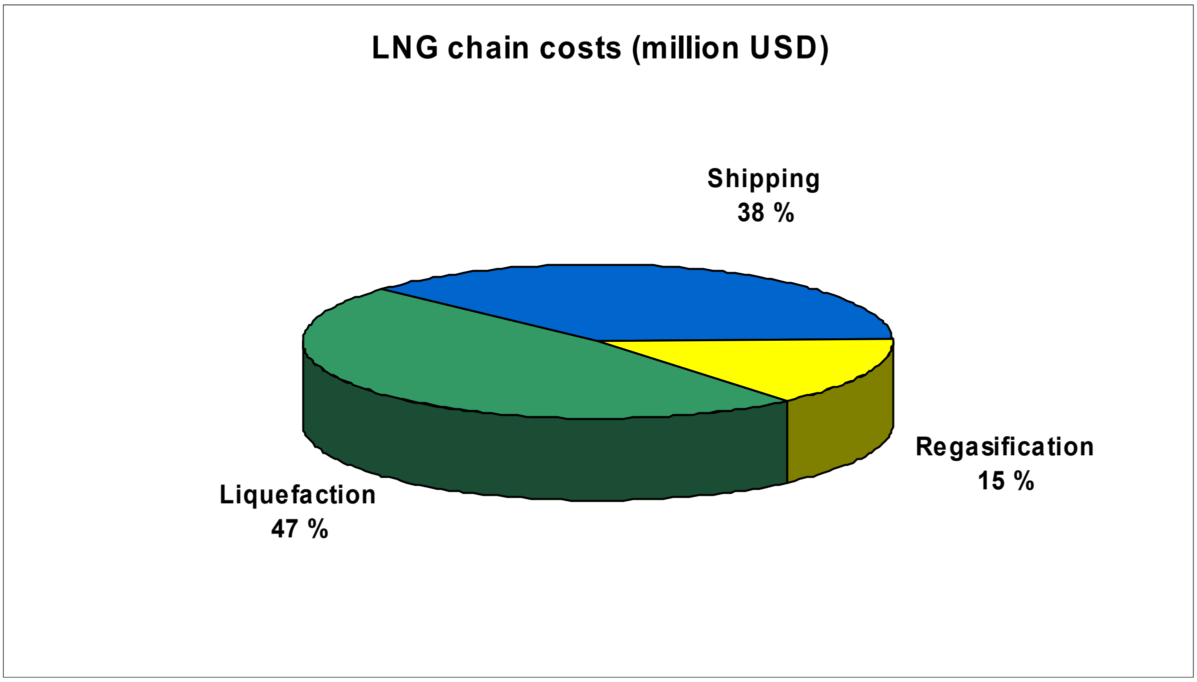
New regasification technologies are being developed, among these, on-board regasification. This means that the LNG is being transformed to gas on the ship and can be pumped directly into the pipeline network, removing the need for on-shore regasification facilities. Furthermore, there are plans for floating offshore regasification terminals and for using pressurized gas. The latter solution would involve the possibility of transferring the gas directly into the grid system. On-board regasification would probably lower costs significantly, as well as increase flexibility, as it would reduce the need for on-shore regasification terminals with long lead times and fixed costs. The experts disagree over the future impact of on-board regasification technology.

The Gas / LNG value chain:



5.3. Cost structure

The cost structure of the LNG value chain has important implications for the market mechanisms. The cost distribution along the value chain will vary among different projects because of differences in factors such as physical and geographical conditions, distance to market and government regulations and subsidies. The numbers provided in this section should thus be seen as a rough estimation. As the upstream and downstream operations, i.e. field development and distribution and marketing are the same for LNG and pipeline gas, I will not cover these parts specifically.



(Figure based on numbers from Clingendael)

Step	***Costs (million USD)***
Liquefaction	900 – 1200
Shipping	850 – 950
Regasification	300 – 400
Total	2050 – 2550

(Clingendael, 2003)

5.3.1. Liquefaction

A greenfield plant with one train of approximately 4 mtpa capacity has an average cost of USD 1bn.[15] Operating costs normally constitute less than 5% of total capital costs pr year.[16] Of the operating expenses, the internal gas consumption constitutes the main part. There are significant economies of scale to be realized in the liquefaction process. In the normal case, a plant with two trains has 20% lower unit costs than a one-train-plant, according to Harang (2002). Furthermore, during the last two decades significant economies of scale have been realised through increasing the size of the trains and storage tanks.[17]

A substantial part of the expected capacity increases in liquefaction plants the coming years is achieved through expansion of existing plants. Expansion projects normally have between a 30% to 40% cost advantage over greenfield projects.

The liquefaction process will typically account for 50% or more of the total cost of bringing the gas to market by LNG.[18]

5.3.2. Shipping

LNG carriers are subject to strict safety regulations and are complicated to construct, bringing the cost of a new vessel (138,000cm) to around $150million. This is more than twice the cost of an oil tanker which is carrying between 4 and 5 times more energy.[19] However, the price of a new LNG-vessel has been nearly halved the last decade. This has been due to several factors, like technological development and the entry of South Korean yards in the LNG segment. Because of the volatile nature of shipping, prices will vary considerably. According to Bakkelund and Sørensen, operating costs for a standard LNG vessel (new 130,000cm) will be roughly USD 16 million per year for a 3000 miles loaded voyage. With China positioning itself as a major ship-builder it seems likely that they can drive the prices of new LNG vessels even further down.

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[15] IEA (2002)
[16] Harang (2002)
[17] Bakkelund and Sørensen (2002)
[18] Harang (2002)
[19] EIA (2006)

The main cost driver regarding the shipping operation is the distance to the market. The larger the distance, the more vessels are needed, thus increasing the financing cost and depreciation cost of the fleet. While the supply of 5 mtpa from Nigeria to Europe would require between 5 and 6 vessels, a similar supply from Algeria would only call for two vessels.

While the shipping operation constitutes around 10% of the delivered value of oil, it takes up between 10% and 30% of the value of natural gas. The transport cost of LNG is a function of the distance, and the capacity of the vessel. Larger vessels can reduce the unit cost significantly, and the average vessel size is indeed increasing.

5.3.3. Regasification

The regasification plant is less expensive than the liquefaction plant. According to Bakkelund and Sørensen, a regasification terminal with a capacity of between 3 and 6 mtpa may cost anything from USD 100 million to USD 500 million. Moreover, a 3.3 mtpa terminal with 200,000cbm storage capacity will have operating costs of around USD 14 million annually.[20] In the reception terminals, storage capacity is the main cost driver. There is a trend of constructing larger storage tanks, making it possible to reap the benefits of economies of scale.

[20] Bakkelund and Sørensen (2002)

5.4. Regional markets

While the market for oil is a truly global market, the gas market has traditionally been divided in three distinct regions. The Asian market is by far the largest, representing 70% of the worldwide market. Japan and South Korea are the two largest LNG importers of the world, importing 81 bcm and 30 bcm respectively.[21] China and India are expected to show significant growth and become major importers during the next decade, according to the predictions in the EIA Energy Outlook. Japan has been driving LNG development as it is an island nation with huge energy demand, few domestic resources and few possibilities for pipeline imports. The major producers supplying this market are Indonesia, Malaysia and Australia. Increasingly, some Middle East producers are starting to export to the Asian market.

The European market is the second largest. Demand for LNG has been steadily increasing during the last decade. Spain has been one of the countries driving the development, and it is expected that the strong demand growth will continue. Main suppliers include Algeria, Nigeria, Egypt and Qatar.

The North American market is also growing, but the growth has been limited until now because of a lack of infrastructure. As of now, the market is small compared to Asia and Europe, and insignificant for the total energy supply. In 2005, LNG only accounted for 2.5% of total US gas supply. It is expected that LNG imports to the US will double between 2005 and 2010.

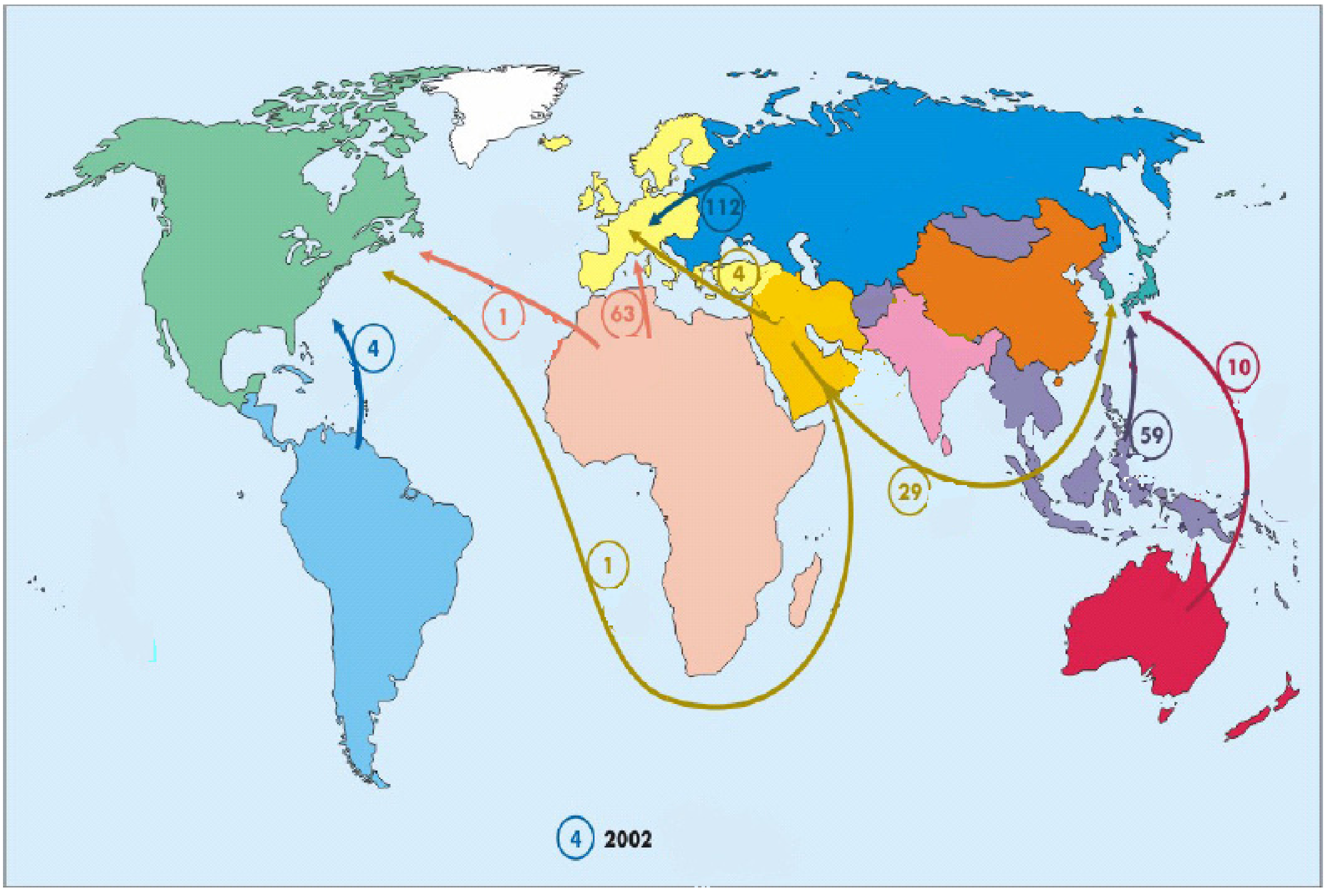
As noted earlier, these regional gas markets have traditionally been separate. However, with the increase in LNG production, the gas markets have been brought closer together. Several of the new and significant LNG producers are located so that they quite easily can supply more than one region. Middle East producers link European and Asian prices as the distance to the European market and the Asian market is quite similar. Moreover, Middle East producers can supply the US East Coast, thus linking all three markets. Examples of this are Qatar, Algeria and Egypt which all supplied all three regions in 2005.[22] As the producers gain more options regarding who to sell to,

[21] IEA (2006)

[22] Some of the delivered volumes were small, but many producers in the Middle East and Northern Africa supplied substantial volumes to two different regions.

the customers gain flexibility as well. As can be seen in the appendix (11.4), Spain imported LNG from sources from all over the world like Oman, Trinidad and even Australia.[23]

In the Atlantic basin, producers like Trinidad and Algeria sell to both Europe and North America.[24]



(Based on map from IEA World Energy Outlook 2004)

This map shows the intraregional trade flows of natural gas in bcm. One should note how Middle East producers supply Asia, Europe and North America.

[23] Imports from Australia were only 0.08bcm, but still it shows that in certain instances it is economically viable to transport LNG over long distances.
[24] BP Statistical Review (2006)

5.5. Market mechanisms and contracts

Because of the complexity and high costs associated with setting up the value chain of LNG, long-term contracts and vertical integration has been the rule of the game in the LNG industry. For example, LNG vessels have traditionally operated on fixed contracts and often been partly or fully owned by the oil companies. The oil companies have also constructed the liquefaction plants in co-operation with construction companies and the host government. The reception terminals have usually been owned and operated by the buyer, e.g. a power producer.

Most LNG projects include the entire value chain, and are thus dependent upon the successful completion and functioning of all the elements in the chain. Securing that all participants have the financial backbone to realize the project, and coordinating the various elements are important for the success of a project. A delay in one part will often cause a delay in all parts of the chain, creating substantial losses.[25]

The contracts in the LNG chain have typically tied up almost all capacity of the different parts of the chain. The concept of "Take-or-pay" contracts (TOP) has been very common. "Take-or-pay" means that the buyer can choose not to receive the gas, but he will nonetheless have to pay for all of or most of the contracted volume.

Long-term contracts have been important to reduce risk in the early stage of the LNG industry, and until five years ago contracts of 20-25 years were the standard. As noted earlier, the investment required for setting up the whole chain is formidable, and risk reducing has therefore been of paramount importance. It has, however, reduced the flexibility of the market. Price signals have been unclear as the amount of LNG traded on spot or on a short term basis has been highly limited.

Cost reductions due to technological advances have boosted the number of LNG projects. With the increasing number of liquefaction and reception terminals, a short-term market has been developing over the recent years. The short-term market was triggered during the Asian crisis when there was surplus capacity in East Asia and high prices in the US.

[25] An example of this is the delay in the construction of a reception plant in Taiwan in 1990, which delayed the Indonesian Train E and the shipping operation. (Weems 2000)

A sign of the developing short-term market for LNG is that more ships are currently being ordered and constructed without being tied to any specific project. The volume of short-term traded LNG constituted 8.9% of total traded volume of LNG in 2003, up from 1.5% in 1997.[26] Although the short-term traded volume is small compared to total consumption it creates flexibility in the market.

New projects still use long-term contracts and no project has yet been done with the intention of supplying on a spot / short-term basis. However, there is a tendency towards shorter contracts because this is demanded by customers, but at the same time contracts are becoming less flexible. It remains to be seen if these contracts are replaced by new ones when they expire or whether some producers will choose to sell on a short-term basis.

Some analysts draw the comparison to the development of the oil market. Earlier it was common for the oil companies to control a large part of the value chain, like the shipping operation. However, at a certain point in time it seems like the market gained sufficient size and flexibility, and the oil companies left the shipping operation to specialized shipping companies. The same development may take place in the LNG business as well, and recently there have been signs of this. According to Hallouche (2006) a spot market based in Zeebrugge, Belgium is developing. Shipping companies have been ordering LNG vessels without having a freight contract in place and the oil companies have been using shipping companies instead of own operations.

However, many analysts doubt that the LNG-market will ever develop into a spot market like that of crude oil. Jensen (2006) argues that the LNG market will never be as flexible as the oil market because of the high costs of LNG transportation compared to the costs of oil transportation. He claims that LNG will only be able to compete in distant markets in the case of over-supply. In such a situation distant suppliers will supply on a marginal cost basis, not on the basis of long term profitability. Emmanuel Soetaert, Gas Analyst in Statkraft AS is of the same opinion and predicts that contracts will become more flexible and of shorter duration, but not disappear. The main argument is that the LNG value chain is too capital intensive to become a market without long-term contracts.

[26] Jensen (2004)

5.6. Pricing

LNG-prices are rarely made public as they are usually part of large bilateral contracts. Traditionally, the price has been linked to the price of fuel oil, not the price of gas, and this is still the most widely used practice in Europe. Most of the volume of LNG is sold under long-term contracts at price determined through negotiations and indexed to the price of fuel oil. Moreover, the Algerian FOB price is an important determinant of the LNG price in Europe, according to Tractebel.

It is unclear how the LNG-prices have developed, and whether there is a price differential between Europe and USA, but LNG and gas prices should be linked indirectly through the oil price, and in theory there should not be large price differences except temporarily during extreme weather. However, the market is far from perfect and in practice it is often difficult to divert LNG to high price areas, and volumes are small. This creates strange price relationships like in 2005 when the price of LNG in Japan was $6.05, while the price of gas at the Henry Hub in the US was $8.79.[27] Because the short-term LNG-market is small, short-term prices can vary intensely.

[27] BP Statistical Review (2006)

6. Natural gas and LNG in Europe today

An overview of over current production, imports and consumption in Europe is provided in this chapter. Understanding the current supply and use of gas in Europe is essential for analyzing the potential for increased use of natural gas in the future, and the potential share supplied as LNG. Current security of supply issues will be covered, as supply diversification is considered one of the most important advantages of LNG compared to pipeline gas.

6.1. History of natural gas and LNG in Europe[28]

The history of natural gas in Europe started with the discovery of the Groningen field in the Netherlands in 1959. Later, gas fields were discovered and developed on the British shelf. In 1965 Britain and France both started importing LNG from Algeria. Spain and Italy followed in 1970 by starting to import LNG from Libya. In the mid-60s Algeria started exporting natural gas through pipelines to the European continent, and during the 70s pipelines brought gas from the Soviet Union and Norway to continental Europe. The late 1990s and the first years of the new millennium saw a strengthened focus on LNG as new producers such as Nigeria and Trinidad came on stream. Nigeria intended to supply France, Italy, Portugal, Spain and Turkey, while the Port Fortin plant in Trinidad would ship part of its production to Spain. Spain also started receiving LNG from Qatar. Norway and Algeria strengthened their position by constructing more pipelines.

[28] If not further commented, this chapter is based on BP.com

6.2. Consumption

I will divide European gas consumption in power generation and household, commercial and industry consumption. Industry consumption is consumption in the chemical industry like e.g. fertilizer producers. Gas demand for power generation is demand for gas which is used in gas fired power plants to produce electricity, which is then used in households, offices and heavy industry. I will focus on gas for power generation as this is where the largest consumption increase is expected. European gas consumption grew by 3.7% pa from 1973 to 2000.

6.2.1. Power generation

Today, power generation consumes around ¼ of the natural gas consumption in Europe, according to the American Energy Information Administration (EIA). In 2003 natural gas accounted for 14% of the energy used for electricity generation.

Natural gas emits significantly less CO_2 per energy unit than coal does, and it is faster and easier to regulate output from a gas-fired power plant than from coal-fired or nuclear power plant.

Substituting old coal fired power plants with new gas power plants will be one of the most important ways to fulfil the obligations of the Kyoto protocol. Currently, a coal-fired power plant emits 850kg CO_2 / Mwh, while a gas-fired power plant emits 300kg CO_2 / Mwh.[29] With equal CO_2 taxes, this will obviously make coal less financially attractive. Recently, the EU commission has proposed even more radical cuts in CO_2 emissions, and these cuts will imply a shift from coal to gas and nuclear power in Europe. Currently, the proposals and new regulations regarding CO_2 emissions and quotas create uncertainty when considering new investments. The price of CO_2 quotas is a major component of the marginal cost of coal fired power plants, and as the price on emissions varies widely, the marginal cost varies widely, which in turn creates unstable conditions for investments.

[29] Numbers are approximations for average plants and for illustration only.

The price on CO_2 quotas in the ETS (Emission Trading Scheme) was approximately 7 €/ton in the beginning of 2005. The price surged to 30 €/ton in July the same year, but has dropped to practically zero in early 2007. This decline is due to over-allocation of quotas for 2007, and prices may rise again next year when the EU decides on the number of quotas to be allocated then. This uncertainty makes it difficult to predict which fuel sources that will prevail in Europe the coming years. Analysts predict that the price of the CO_2 quotas needs to be 30€ before it is profitable to switch from coal to gas.[30]

There are strong differences in the use of gas for power generation between the Western European countries. The UK has for some time used natural gas extensively as fuel for base-load production, while other countries have used it to a lesser degree mainly for peak-load purposes. Spain completed ten new gas-fired power plants in 2004 with a total output of 8400MW. Over the last five years gas consumption in Spain has risen by 14% annually (cumulative annual growth rate).[31] LNG constituted 62% of Iberian gas consumption in 2005.[32] Due to favourable incentive mechanisms from the government, the use of wind power is increasing in countries like Spain and Germany. As wind power generation is unreliable, this increases the need for easily regulated capacity, which means gas power.

6.2.2. Household and industry consumption

Most Western European countries have an extensive gas grid for household use.[33] The gas is used directly for heating and cooking instead of first transforming the energy to electricity. Direct household and commercial consumption account for 40% of total gas consumption.[34]

[30] Statkraft Presentation (2007)
[31] The World Energy Book (2006)
[32] The World Energy Book (2006)
[33] An exception is Norway which, despite abundant gas reserves, does not use gas directly in household consumption. This is due to the traditionally low electricity prices.
[34] IEA (2002)

6.3. Supply

In this section I will treat how Europe currently is supplied with natural gas. I will divide supplies in three, indigenous supply, pipeline imports and LNG imports.

6.3.1. Indigenous supply

The UK is the largest producer of natural gas within the EU with a production of 92.0 bcm in 2005, down from 111.2 bcm in 2001.[35] The production is solely offshore production in the North Sea and most of the fields are in a mature phase.

The very large gas field Groningen made the Netherlands an important gas supplier. This field has now been in production for approximately 40 years. Production has been fairly stable the last decades with a production of 78.8 bcm in 2005. The Netherlands export over half of their production to other European countries.

Germany, Italy and Denmark also produce certain amounts of natural gas with 19.9, 12.0 and 10.4 bcm respectively in 2005.[36]

Norwegian production increased by 60% between 2000 and 2005. Production reached 89.6 bcm in 2005. According to the Norwegian Ministry of Petroleum and Energy, Norway exported 82.5 bcm in 2005. Norway exports 30% of its gas production to Germany, 18.8% to Britain and 19.3% to France. The new offshore gas pipeline “Langeled” supplies the UK with 80 mcm of gas per day from the Ormen Lange field, which equals 29.2 bcm a year.[37]

The R/P-ratio for OECD Europe has been relatively stable at 20 years the last years due to new discoveries in the North Sea and in the Norwegian Sea.[38] Norwegian authorities believe there are 5000 bcm of recoverable reserves left on the Norwegian shelf, of which Troll contains 1085 bcm, Ormen Lange contains 375 bcm and Snøhvit contains 160 bcm.[39] The proved reserves are 2410 bcm according to BP.[40]

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[35] IEA (2006)
[36] IEA (2006)
[37] Norwegian Ministry of Petroleum and Energy (2006)
[38] IEA (2002)
[39] Norwegian Ministry of Petroleum and Energy (2006)
[40] BP Statistical review (2006)

6.3.2. Imports by pipeline

Pipeline is the main way used to supply Europe with natural gas, providing a constant flow of gas from the three main producers, Russia, Algeria and Norway. 75% or 127.8 bcm of natural gas imports to Western Europe from none-European countries come through pipeline.[41]

Russia is the major pipeline supplier with 86.0 bcm of supplies to Europe, all of which goes through pipeline.[42] In addition, Norway supplies the continent and the UK with 76.5 bcm. The Norwegian production has been rapidly increasing from the mid-90s with the contribution from the Troll and the Ormen Lange field.

Algeria has been a major supplier of gas to Europe from the 1960s and is an important pipeline supplier for Southern Europe, providing 37.3 bcm of gas to Italy and Spain by pipelines through Tunisia and Morocco respectively. The Enrico Mattei pipeline to Italy has a capacity of 27 bcm per year, while the Pedro Duran Farell pipeline to Cordoba in Spain can transport 13 bcm per year. Algeria has vast reserves of approximately 4580 bcm and its production has been rising during the last years to 87.8 bcm in 2005.[43] Libya supplies Italy with 4.5 bcm per year through an offshore pipeline.

[41] Appendix 11.3
[42] Appendix 11.3
[43] BP statistical review (2006)

6.3.3. Imports of LNG

Western Europe receives 25% of their imports from non-European countries by LNG. Algeria is currently the most important LNG-exporter for Europe with deliveries to France (7.5 bcm), Spain (5.2 bcm), Belgium (2.9 bcm), Italy (2.5 bcm) and the UK (0.5 bcm). Total Algerian LNG supplies for Western Europe reached 18.5 bcm in 2005.[44]

Europe has consumed LNG from Nigeria since 1999 and total import has now reached 10.8 bcm with Spain and France being the main importers. Egypt and Qatar have also increased their LNG export to Europe lately and they both supply between four and five bcm, mostly to Spain. Moreover, Europe receives some minor LNG volumes from other sources such as Oman, Libya and Trinidad and Tobago.

Spain is the most significant European LNG importer with total imports of 21.9 bcm in 2005. LNG now makes up 2/3 of total Spanish gas imports. France is the second most important importer with LNG imports of 10.5 bcm in 2005. Italy imports 2.5 bcm from Algeria and the UK is currently resuming LNG imports with three reception terminals.

[44] Appendix 11.3

6.4. Security of supply

Security of energy supply is currently an important issue in Europe, with indigenous gas production decreasing each year. Analyzing the current situation and how LNG may play a role in improving security of supply is important in order to reach a conclusion on future demand for LNG in Europe.

There are both short term security of supply issues such as extreme weather, technical failures and accidents, as well as long term security of supply issues like conflicts and lack of investment.

Securing a stable supply of energy has always been one of the top priorities for every country. Furthermore, the majority of the world's energy reserves are located in regions with less political stability than most of the net importing regions. In Europe, this issue is becoming increasingly important as the indigenous production (except Norway[45]) is declining. Western and Central Europe (including Norway) is currently importing 35% of its natural gas consumption, a figure which is anticipated to increase to 70% by 2020 and 80% - 90% in 2030.[46]

Most of Europe's gas imports today arrive through pipelines, mainly from the three large exporters; Russia, Norway and Algeria. For decades, the import dependency on the Soviet Union and Russia has been the most important issue regarding the security of stable gas supplies. During the cold war, OECD advised European countries not to become too dependent on the Soviet Union, and preferably to have less than a certain percentage of their imports coming from the Soviet Union. Still, the gas supplies were stable throughout the cold war, and through the rather chaotic transition period, giving the Soviet Union/Russia a reputation of a trustworthy supplier.

This reputation was severely hurt on the 1st of January 2006. Ukraine has for years relied on cheap gas from Russia, but lately, the state-owned Russian gas company, Gazprom, has tried to increase the price. The dispute took a very serious turn when Gazprom shut down all gas supplies to Ukraine for one and a half days in a tactical move to put pressure on the Ukrainian pro-EU government. This obviously had severe consequences for Ukraine, but also for Western Europe. Russia supplies 35%

[45] In this chapter I will treat Norway as part of Europe as it is the most relevant in a discussion of security of supply.
[46] UNECE (2003)

of Western Europe's gas consumption, and 80% of this transits Ukraine.[47] Therefore, the supplies to Western Europe were restrained as well.

The incident with Ukraine has been followed by other similar examples of Russia using its power as a major energy supplier in order to increase gas prices or punish countries which disagree with Russia. Georgia and Belarus have been in this situation during 2006, and in May 2007 Russia cut off energy supplies to Estonia, which is an EU member, apparently because of political disagreements over a Soviet war memorial from the Second World War.[48]

Furthermore, there are serious concerns regarding underinvestment in Russian gas industry, as Gazprom seems more focused on buying Turkmen gas instead of maintaining the production rate at their own fields.

Norway has for years supplied the European continent with natural gas through offshore pipelines from its North Sea oil and gas fields. Being a politically highly stable country and member of NATO and EEA, Norway has been a safe supplier. However, its reserves in the North Sea are declining and are small compared to those of Russia and The Middle East. The reserves in the Barents Sea and new LNG projects there may ensure that Norway remains a stable supplier to Europe.

Algeria is today a relatively calm country compared to in the 90s. The conflict between the government and Islamic opposition took a violent turn in 1992, and six years later approximately 100,000 people had died. After the opposition was defeated the country has been relatively stable, but there are substantial social problems in the country and armed opposition still exists. Despite political unrest, Algeria has been a highly stable supplier of natural gas to Europe. There are import restrictions in place in Spain, where transporters can not import more than 60% of the gas from the same country. This means that Spanish companies will have to look for other sources than Algerian gas, as this currently makes up almost half of Spanish gas imports.[49]

Even though there are political risks associated with importing gas from Russia and Algeria, the income from these trades are of paramount importance to the two countries and they have little

[47] IEA (1998)
[48] Officialy, the supplies of gas, oil and coal were cut off because of a sudden lack of trains for transportation.
[49] Appendix 11.3 and 11.4

incentive to cut supplies for political reasons as long as they are relatively poor countries. There are probably more concerns to be raised over the transit countries which do not take part in the profit in the same way as the producers.

One of the serious disadvantages of pipeline transport is that pipelines from Russia and the Middle East have to cross several borders in order to reach Europe. Political turmoil, sabotage or armed conflict in the transiting countries can hinder the gas flow. This was highlighted by the Russian/Ukrainian gas price dispute and the subsequent supply interruption.

LNG has several advantages over pipeline transport regarding security of supply. Firstly, a cargo of LNG will usually not have to pass several borders, as it can travel in international waters to the destination. Secondly, the vessels and the reception terminal can receive LNG from alternative producers in the case of a halt in production, while a pipeline can not be moved to another country. This presumes that there is readily available liquefaction capacity elsewhere, which might not be the case.

At the same time, there are several threats to the safe supply of LNG. The LNG carriers often have to pass straits that are strategically important on their way to Europe. From The Middle East they will need to sail through the Suez Canal and from the Black Sea ships have to sail through the Bosporus strait. The closing of, or congestion in, any of these may seriously hinder supplies.

Diversification is seen as one of the most important ways to enhance security of gas supply to Europe. As long as pipelines from the Middle East are difficult to construct because of geopolitical issues, LNG may be the main vehicle to increase diversification.

In conclusion, security of natural gas supply is a major issue for Europe and the flexibility and diversification offered by LNG will make LNG attractive from a security of supply point of view. This will enhance the predicted growth of LNG in Europe.

7. The future of natural gas and LNG in Europe

This chapter will analyze the potential for increased use of natural gas and LNG. I will consider the demand and supply side separately. This means that if I predict an expansive shift in the demand curve, consumption is predicted to increase, and vice versa. When I for example include consumption forecasts from the IEA in the demand section, it is important to note that these estimates assume a certain shift in the supply curve / production increase as well.

Firstly, I will discuss future gas demand. I will do this by using two scenarios and some general considerations regarding future demand. Next, I will consider the future of LNG as opposed to pipelines by analyzing the competitiveness of LNG compared to pipeline as a means of transportation. Plans for new reception terminals will be analyzed in order to see whether importers are committed to importing LNG.

In order to analyze the supply side, I will start by using a formal model to gain insights into new investments in LNG capacity. Then an overview of potential new suppliers of LNG is presented. Finally, the competitiveness of Europe in attracting new LNG supplies compared to the other regional markets will be analyzed.

7.1. Demand

The conclusion from section 6.2 was that natural gas is currently in strong demand in Europe because of its flexibility and relatively small adverse environmental effects. In this section I will discuss the future demand for natural gas in Europe. If the growth in gas consumption is expected to continue, will the gas be transported by pipeline or as LNG? And are importers proving their commitment by constructing reception terminals?

7.1.1. Demand scenarios

In the prediction of the gas market, as in other energy markets, it is useful to work with scenarios. This is due to the fact that it is often very difficult to predict one development or one scenario that is much more probable than other scenarios or possibilities.

I will use scenario analysis to analyze the future role of LNG in Europe in two different scenarios. The scenarios differ in how the gas price develops the coming years, and how this affects consumption. The purpose is to show how the future of LNG in Europe can be significantly different in the two scenarios.

7.1.2. Scenario 1: Strong growth in gas demand

There is a strong case for increasing gas demand in Europe over the coming years. As discussed in 6.2.1, natural gas has several important advantages in electricity generation. These include high flexibility in production with the possibility of covering increasing peak load demand, low CO_2 emissions compared to the current coal power technology and higher effectiveness and potential than renewable energy sources.

The IEA predicts the very strong growth in demand for natural gas to continue. IEA predicts gas demand in OECD Europe to be at 2.1% p.a. over the coming years, reaching a consumption of 901 bcm in 2030, twice as much as in 2000. The major part of this growth is assumed to be in power generation. This is especially the case in countries like Italy and Spain, while countries like Great Britain already use much gas in power generation.

There are some important assumptions to be mentioned for this scenario to hold. The increased demand for gas must be met with increased supply in order to not inflate the gas price too heavily. This increased supply will be imported from outside Europe as EU and Norwegian reserves are limited and declining. This will require massive investment in production and transportation capacity. It is assumed that a certain part of the increased supplies will come through pipelines from the Middle East, Northern Africa and possibly from Central Asia / Russia. Due to limited reserves in the most convenient areas, difficulty of constructing pipelines through politically unstable countries and declining costs in the LNG-chain, it is highly likely that a significant part of the increased supply will come as LNG. Pipelines from the Middle East countries like Iran are possible, and could supply Europe with large quantities of gas, but there are in the foreseeable future severe security of supply issues related to relying on stable supplies from the Iranian and other regimes in the region.

I will therefore conclude that in this scenario, demand for LNG will increase strongly, given the same low level of intra-regional gas competition as of today. I believe that LNG supplies will increase strongly both in absolute number and relative to pipeline imports.

There is one potentially strong impediment to such increase in supplies, namely strong demand from the other gas consuming regions of the world. As North American gas reserves are low and rapidly declining,[50] there are reasons to believe that the coming shortfall of indigenous production will have to be made up by a massive increase in imports. The financial strength of this region may make it hard to compete with. I will come back to this in section 7.2.3 and 7.2.4.

Furthermore, the economic growth in China and subsequent growth in demand for energy in general and gas in particular may redirect important gas flows from Russia and Central Asia to China. However, this might lead to increased demand for LNG in Europe, as less gas can be imported from Russia and Central Asia.

[50] The R/P-ratio for USA is 10.4

7.1.3. Scenario 2: High gas prices limit demand

The latter years have seen gas prices surging. Steady growth in demand, combined with inability to expand total production capacity in the same pace, has doubled prices over the last five years. (BP statistical review) The gas price is strongly linked to the oil price,[51] which has increased fiercely due to world economic growth, increasing exploration and exploitation costs and political instability.

In this scenario, these trends are assumed to continue. The unprecedented growth in China will continue, North American energy reserves will diminish and indigenous gas production in Europe will continue to decline. The consequent pressure for oil and gas globally will drive prices upwards. The political and economic power of the US will ensure that the US captures most of the LNG from Trinidad, Venezuela, Russia and Norway. The result will be less gas flowing to Europe, driving the prices upwards.

A significantly higher gas price will lead to the substitution of gas in power generation by nuclear and new less polluting coal plants.[52] Gas demand in the chemical industry will not easily be substituted, but household consumption can be substituted by electricity generated by nuclear and coal fired power plants. As we saw in 6.2.1 power generation is assumed to be the largest growth area for gas in the future. If high prices limit gas-for-power consumption, the total consumption growth for gas in Europe will be limited.

In Britain, higher gas prices have already led to a shift from gas to other energy sources in new generation capacity. However, Britain generates a substantial part of their base load using gas, so new gas fired power plants will not be able to reap the benefits of the flexibility in gas fired plants in the same way as in energy systems with little flexible capacity.

If demand does not fulfil the expectations of IEA and other analysts, LNG will probably lose out as it is a rather high-cost alternative as of today. LNG is more likely to become a niche supplier, and a stagnation of gas demand will limit demand for LNG.

Hence, I conclude that in a scenario with increasing prices which in turn leads to substitution of gas in power generation, demand for LNG will stagnate and achieve a minor role in the European gas markets.

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[51] It is common in gas contracts to link the price in the contract to the oil price

[52] 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.

7.1.4. General demand forecasts

Natural gas is expected to be the fastest growing energy source in Europe the coming decades. IEA forecasts the increase in OECD Europe gas demand to be 2.1% pa from 2000 to 2030. This means a growth from 482 bcm in 2000 to 901 bcm in 2030.[53]

Direct household consumption is expected to increase by 1% pa until 2030 according to IEA. The same figure for industrial use is 0.8%.

Strong growth in gas consumption for power generation is expected the coming years and decades. EIA believes that almost 60% of the increased gas demand until 2030 will be for power generation, while IEA predicts 72%. Increased use of gas in power generation will be the main driver for a strong growth in demand for natural gas in Europe. Moreover, EIA expects that gas will account for 24% of the energy used for electricity generation by 2015 and increase further to 32% by 2030.[54] According to these projections, natural gas will become the preferred choice of fuel for new power generation capacity in Europe the next decades. It is important to note that higher than expected CO_2 prices may make nuclear power generation more profitable and thus limiting the growth in gas consumption.

There are differences within Europe regarding predictions for future gas consumption. In Britain, gas use is not expected to increase because of price increases and the already widespread use. Some countries like Spain and Italy are expected to increase the use of gas-fired power plants heavily in the coming years.

As heavy industry moves out of Western Europe, household consumption will make up a larger part of electricity consumption. Household consumption varies substantially more during the day and with the temperature thus demanding electricity generation that is easily regulated. Therefore, the need for peak-load capacity compared to base-load capacity will be greater over the coming years, and this will especially favour natural gas over nuclear and coal. Natural gas is expected to be more financially attractive than renewable energy sources in the near future.[55]

These arguments make a strong case for natural gas in Europe the coming years.

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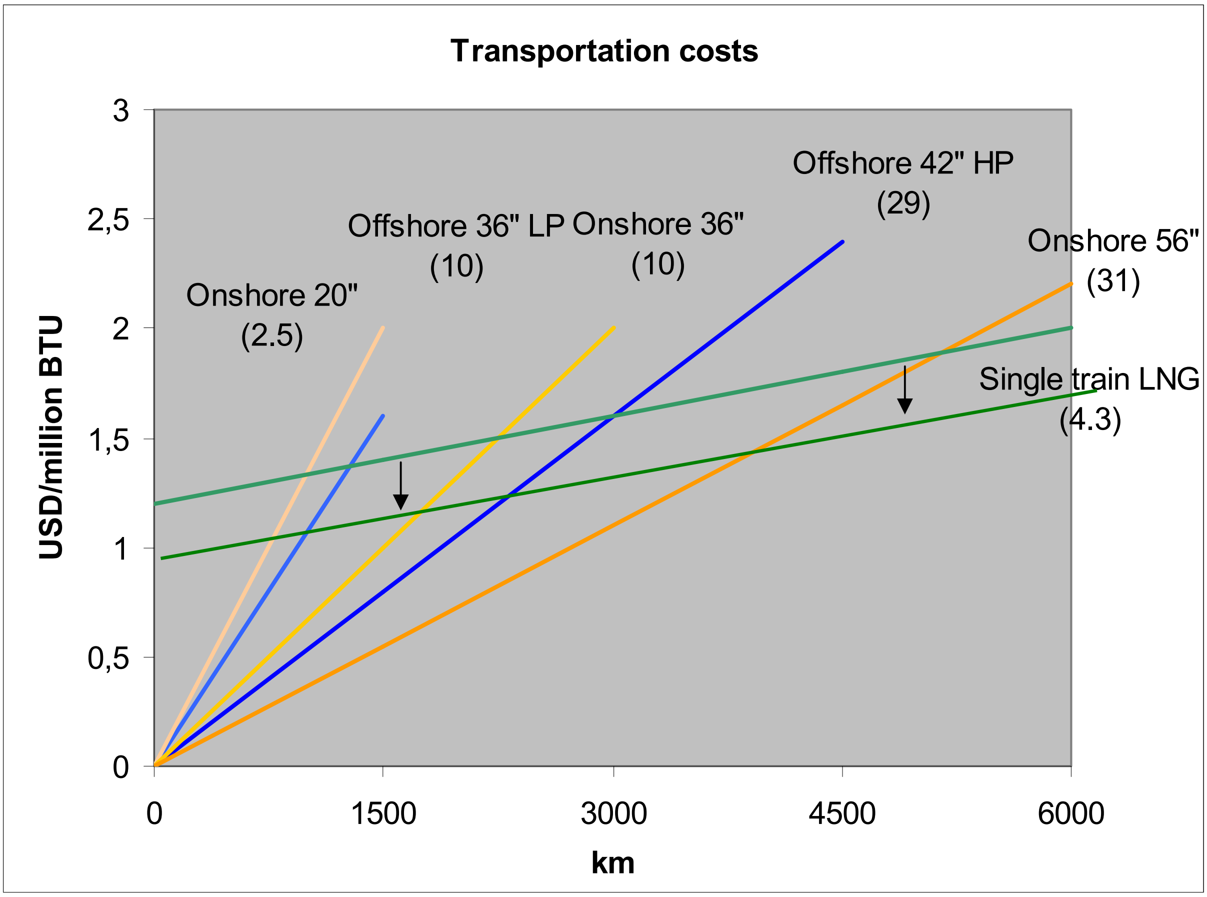
[53] IEA (2002)
[54] IEA (2006)
[55] There is little hydropower potential left to be exploited in Europe and technologies for sun, tidal, osmosis and offshore wind power are still poor and expensive.

7.1.5. Use of LNG vs. pipeline transport



Cost reductions in LNG transportation would reduce the slope of the curve showing the relationship between cost per BTU and distance, as shown in the figure above. There are some economies of scale from using larger vessels. The tendency is increasing size of the vessels, so one should expect unit costs to come down.

Cost reductions in liquefaction and regasification will lower the starting point of the curve showing the relationship between cost per BTU and distance. There are economies of scale from having two trains instead of one and from making larger trains.[56] Increasingly larger trains are being constructed and unit costs decrease.

[56] Approximately 20%, section 5.3.1

As long as pipeline costs are fairly stable, the technological progress in LNG lowers LNG unit costs relative to pipeline unit costs, with the effect of making LNG economically feasible for more gas projects. This will make LNG able to compete with piped gas in projects with large volumes.
A decisive aspect is where the new gas supplies to Europe will come from. Potential new supplies from Central Asia will probably be transported by pipeline while new supplies from Nigeria and/or Qatar will come as LNG.

There are plans for pipelines from Russia, Algeria, Egypt, Libya, The Middle East and The Caspian Basin. Algeria has particularly concrete plans for offshore pipelines to Italy and Spain. There are plans for LNG supplies from North Africa, The Middle East, South America and Norway.

LNG adds more flexibility for producers. Increasingly higher flexibility and shorter duration of LNG contracts make it possible for the producer to redirect shipments to areas with higher prices. Historically, there have been significant price differences between regions and the LNG exporter would be able to exploit these by redirecting the shipments while a pipeline exporter would not have this option. This possibility should be treated as a real option in the supplier's decision analysis. Some part of such price differentials is due to a large portion of LNG consumption instead of piped gas consumption. This is the case in Japan and to a certain degree in the UK.

The conclusion is that the increased European demand will be covered by a combination of LNG and piped gas. Cost reductions in LNG will make it more attractive, but the extent of its future use depends on many factors treated in this paper which I will come back to in the final conclusions.

7.1.6. Planned reception terminals

In order to determine future LNG consumption in Europe it is important to consider the number of reception terminals under construction. Because of the significant investment needed this is a strong signal of commitment. Currently, several new reception terminals are being constructed and planned in Western Europe. Moreover, there are many expansion projects underway.

UK is expanding its reception capacity even further with an expansion project in South Hook LNG, Milford Haven, which will double capacity from 10.5 bcm/year to 21 bcm/year in 2010. The Dragon LNG project in Milford Haven will be completed in 2007, receiving 6 bcm/year. There are plans for expanding the Isle of Grain terminal and constructing a new terminal in Anglesey, Wales.

In Italy, around ten new terminals are under planning. According to Soetaert, there may come two or three more LNG-terminals in Italy, but not as many as suggested by some. The La Spezia terminal is expanding capacity, and Edison LNG Riviso is under construction.

In Spain, there are talks of expanding the terminal in Barcelona. A new terminal in Reganosa is under construction, and there are expansion projects underway in Sagunto (Valencia), Bilbao, Cartagena and Huelva.

The Sines terminal in Portugal is due to complete an expansion from 5.2 bcm/year to 8.5 bcm/year during 2007. In Belgium, the terminal in Zeebrugge is doubling its capacity from 4.5 bcm/year to 9bcm/year of gas, in a project that will be completed in 2007.

In France, the Fos Cavous is expanding and is due to be finished in 2007. A new terminal is being constructed in Verdon that will enter operations in 2010. Additionally, there are talks of reception terminals in the Netherlands and in Germany.

To conclude, substantial investments are being made in LNG reception capacity in Europe. This is a strong indicator of increased future use of LNG.

It is not likely to get a situation with over-capacity in LNG-reception. The reason for this is the high risk taken on by the last actor to invest in reception capacity. If demand drops, the last one to construct a reception terminal will incur heavy losses if he is not secured by long-term contracts, and long-term contracts are becoming more seldom. This will discipline the actors in the reception terminal business.

(King&Spalding, 2006)

The map shows existing terminals, terminals under construction and proposed terminals. Relatively few of the proposed terminals are expected to be realised, but many of the existing ones are expected to be expanded. Currently, there are between 38.8 and 44.8 bcm of reception capacity under construction and between 34 and 49 bcm are under planning.[57] The French commission for deregulation of energy markets, CRE, predicts European import capacity to increase from 50 bcm in 2004 to 145 in 2010.

[57] CRE

7.2. Supply

In order to predict the future of LNG in Europe I will now consider the supply side. Firstly, there is a need for more liquefaction capacity supplying the Atlantic market, either by increasing production from existing sources or by the entrance of new suppliers. Secondly, Europe must attract a certain part of that production increase.

7.2.1. Theoretical approach to increasing gas supplies

In order to gain further insight into the mechanisms regarding investments in gas supplying capacity I will present and apply a model from Hannesson (1998). In Hannesson (1998) this model describes a market with third party access to a gas pipeline and two sellers. In this market there is one low-cost and one high-cost producer, and the model analyzes their decision to invest or not to invest in new production capacity.

I will use this model in order to analyze a situation with one buyer of gas (e.g. the national gas company), and two kinds of suppliers. One of the kinds of suppliers has low production costs, while the other has high costs. Due to security of supply issues there is a desire not to import more than a certain percentage of total imports from the low-cost suppliers, even if this was possible. The low-cost / high-risk suppliers will consist of Russian piped gas, Algerian gas and potential supplies by e.g. Iran. High-cost / low-risk suppliers would be EU indigenous supply, Norway (both pipe and LNG) and LNG from Australia, Trinidad and Brunei. I assume that the two groups act like two players, which means that the suppliers in each group behave similar to the other members of their group because they coordinate their actions. After that I will use the framework to analyze the effect of having more buyers and liberalizing the obligation to import a certain part of total imports from each supplier.

Demand for natural gas is given by the linear demand function:

$P = a - bQ$ (1)

Transportation costs are ignored and P is the price net of such costs.

Because of security of supply issues like those described in chapter 6.4 the buyer will diversify its supplies by importing a fixed share, α, from the low-cost producers, and thus a fixed share, 1-α, from the high-cost producers.

This gives us

$Q1 = \alpha Q$ and $Q_h = (1- \alpha)Q$, $Q_l + Q_h = Q$ (2)

We assume that α is both known and fixed, although this might very well not be the case in real life. There are good reasons not to disclose security of supply policies. Moreover, it is not likely that the importing region will have an entirely fixed α. The total profit of the gas purchase will be

$P(Q)Q - \alpha QC_l - (1 - \alpha)QC_h$ (3)

as the prices paid to the producers from the importer net out. Maximizing the total profit to be shared leads to

$P + P'Q = \alpha C_l + (1 - \alpha)C_h$ (4)

Which gives us the profit obtained by each group of suppliers

$\pi_l = Q_l(S_l\text{-}C_l)$, $\pi_h = Q_h(S_h - C_h)$ (5)

and the profit obtained by the importer will be

$\pi_{imp} = Q_l(P(Q) - S_l) + Q_h(P(Q) - S_h)$ (6)

If assuming that the importer and the producers will share the profit equally

$S_l = C_l + ½(P - C_l)$, $S_h = C_h + ½(P - C_h)$ (7)

If we use the values a = 10, b = 1, Cl = 2, Ch = 4 and α = 0,5 we get Q = 3.5, P = 6.5, Sl = 4.25 and Sh = 5.25.

The price paid to the producers varies from 4.25 to 5.25 which is a substantial price difference. This price difference exists because of the obligation to diversify the imports. As long as this obligation is in place one may observe that importing countries like Spain may be willing to pay more for LNG from Norway than LNG or piped gas from Algeria. As will be mentioned later in this paper, Spanish companies have an obligation not to import more than 60% of their gas supplies from one single country. A price difference like the one shown in the analysis above will give different investment incentives in different regions. Producers which are considered safe suppliers may invest in projects with higher costs than producers which are not considered safe suppliers because the safe suppliers can charge a higher price for the gas.

What if the market is liberalized, more actors are allowed to import gas and the obligation to buy half of the total quantum from each supplier is relaxed? This is partly what has happened in Europe lately, with a liberalization and deregulation of the gas market, the entrance of new importers like power companies importing LNG, and the relaxation of import restrictions on Russian gas as the cold war has ended.

In order to analyze this we will have to classify the competition between the two groups of suppliers. The conventional classification separates between whether price or quantity is the decision variable. With price as decision variable, Bertrand competition, the low-cost producers will lower their price to a level marginally below the marginal cost of the high-cost producers, thus capturing the entire market. The only way for the high-cost suppliers to be present in the market would be for reasons of diversification. Otherwise there would be no place for the high-cost suppliers until the low-cost suppliers have exhausted their resources. This kind of competition assumes that the low-cost suppliers have capacity to supply the needed quantity at a fixed marginal cost, an assumption that is highly unlikely.

The other possibility is competition with quantity as decision variable. This is more likely due to the high capital costs involved in building new production capacity. With quantity as decision variable each group of suppliers would decide on how much gas to supply, taking into account the amount supplied by the other group of suppliers. There will be no price difference between the two groups of suppliers as there is no security of supply constraint. One can separate between the situation where both make their decision simultaneously, Cournot competition, and where one of the players has the advantage of being the first to make the decision, Stackelberg competition. I will here analyze the situation using Cournot competition.

The revenue (R) of supplier i will be given by multiplying the price by the quantity sold by the same supplier (Q_i):

$R_i = aQ_i - bQQ_i$, $i = l,h$, $Q = Q_l + Q_h$ (8)

The marginal revenue, given the quantity supplied by the other supplier, will be

$a - bQ_j - 2bQ_i$, $i,j = l,h; j \neq i$ (9)

For each player, the optimum solution will be where his marginal cost equals his marginal revenue. In order for the solution to be consistent, the quantity supplied by each must end up being the same as the other supplier assumed. Setting the marginal revenues equal to the marginal cost and solving the equations gives us

$Q_i = (a + C_j - 2C_i)/3b$, $i,j, = l,h; j \neq i$ (10)

This solution returns values of P = 5.33 and Q = 4.67 which consists of Q_l = 3.33 and Q_h = 1.33. π_l will be marginally less than 12 under Bertrand competition and 11.09 under Cournot competition.

As shown, the high-cost suppliers will lower their quantum, while the low-cost suppliers will increase their quantum compared to the situation where buyers were obliged to buy half of their supplies from each supplier. The net effect will be an increase in supplies as the low-cost suppliers will increase supplies by more than what the high-cost suppliers lower supplies by. In practice, high-cost suppliers may lower their supplies even more because of declining reserves and higher costs for the gas that is left. I will now include this aspect of different and finite reserves.

The models above treat the supply of gas as being infinite, but this is untrue as gas is a finite and exhaustible resource. The following model takes the time aspect into account.

The high-cost suppliers have 50 units of reserves, while the low-cost suppliers have 100 units. This fits well with the reserves overview in chapter 4, although the difference is larger than 50 to 100. Their initial production capacity is 1.75 each. We saw that under Cournot competition the low-cost suppliers would like to supply 3.33 units. To do this, the low-cost suppliers must expand capacity by 1.58. There is a certain lead time for this expansion project. The present value of the profit for supplier i can be expressed as

$$\int_{0}^{T_1} P(\sum Q_{1,j})Q_{1,i}e^{-rt}dt + \int_{T_1}^{T_2} P(\sum Q_{2,j})Q_{2,i}e^{-rt}dt + \int_{T_2}^{T_3} P(\sum Q_{3,j})Q_{3,i}e^{-rt}dt - K_i$$

The future is here divided in three phases. The first phase is the time it takes to build the new capacity, thus the quantum will be at the current level. The second phase is where the new capacity has come on stream and both the low-cost and the high-cost suppliers are producing. In the last phase, the suppliers with the least resources have run out of reserves and there is only one group of suppliers still producing. K is the present value of the investment in new capacity and r is the discount rate. Operating costs are ignored.

We now assume that both the low-cost and the high-cost suppliers have the possibility of doubling their capacity at a cost K. The lead time will be five years (T = 5) and because expanding production capacity is visible, it is assumed that both kinds of suppliers will be able to increase their capacity simultaneously.

If both invest in new capacity the price will decline to 3, while if only one of them expands, the price will be 4.75. If the low-cost producers with large reserves choose to expand, their price will be 6.5 in the last period compared with 8.25 if they keep their capacity unchanged.

The figures 2 and 4 which are inserted into (7) can be interpreted as the cost per unit per year for the low-cost and high-cost producers respectively. This is thus the break-even price. For r = 0.1 the present value at time zero for an annual production of 1.75 until the reserves are emptied is 66 for the high-cost producers at a price of 4, and 35 for the low-cost producers at a price of 2. If production is starting at time zero and the cost of doubling the capacity is the same as the cost of initial capacity, 66 and 35 would be the values for K for the two kinds of producers. In the payoff matrix below are the results for the two producers in the four different situations.

High-cost / Low cost	No investment	Investment
No investment	107.2 ; 115.0	90.4 ; 103.9
Investment	48.6 ; 106.1	22.8 ; 86.1

Payoff to high-cost producers ; payoff to low-cost producers

The dominant strategy for either supplier would be not to invest, regardless of what the other does. The result of liberalisation and relaxation of the obligation to diversify will in this case be that the suppliers do not want to increase capacity. However, this result depends totally on the cost of new capacity. If the cost is 20 and 10 respectively, the result would be as shown in the matrix below.

High-cost / Low cost	No investment	Investment
No investment	107.2 ; 115.0	90.4 ; 128.9
Investment	94.6 ; 106.1	68.8 ; 111.1

Payoff to high-cost producers ; payoff to low-cost producers

In this case the low-cost suppliers will choose to invest, while the high-cost suppliers will refrain. The capacity will increase to 4.25 and the price will fall from 6.5 to 4.75 in phase two.

This shows that the cost level of new capacity is important, and can be critical to new investments. This is a relevant and important conclusion as the costs of the LNG chain have declined over the last years, and are expected to continue declining. This may make new LNG projects like supplies from the Middle East more likely.

Furthermore, the analysis above shows that the high-cost suppliers lose when relaxing the security of supply-alpha. This is natural, as there would be less incentive to pay more for low-risk supplies if one is not obliged to do so. With ever-changing international relations, security of supply may soon increase in importance and low-risk suppliers might be able to charge a higher price if the market and the European governments attaches a risk-premium to gas from certain sources.

7.2.2. New LNG production capacity

The literature seems united in predicting that the Middle East will become the fastest growing LNG exporter in the years to come. The region has vast gas reserves and some of the countries are eager to monetize their gas resources. The most important feature of LNG from the Middle East is that it can economically supply all three regional markets, East Asia, Europe and North America. With contracts being of increasingly shorter duration, this may mean that the Middle East producers act opportunistically, selling to the region with the highest prices.

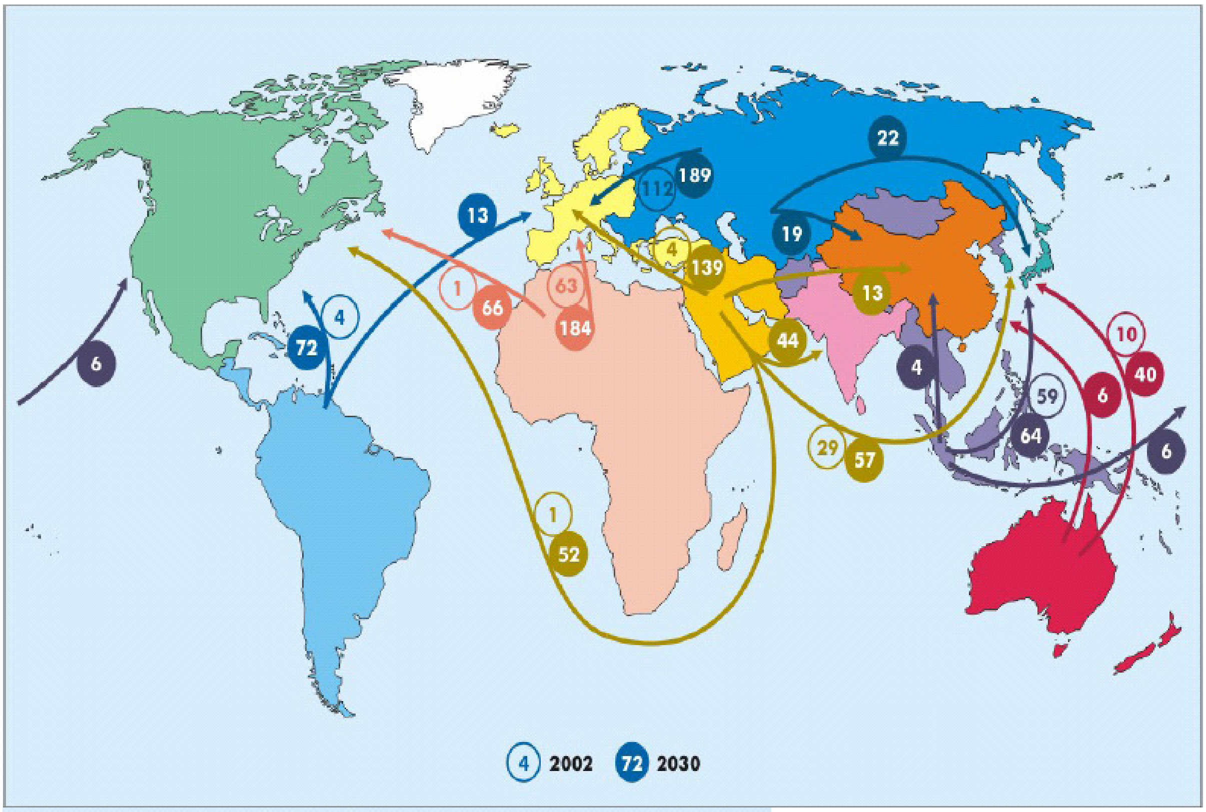
The countries in the Middle East will probably start increasing exploitation of their enormous gas reserves soon, and they will probably export a significant share of their production to Europe, as well as a certain share to Asia. Oman and Qatar will increase their production. Saudi gas reserves are located inland and their exploitation will be more complex than in many other countries. Qatar has been a driving force of LNG development in the Middle East, and according to Jensen (2004) Qatar will continue to aggressively pursue new opportunities.

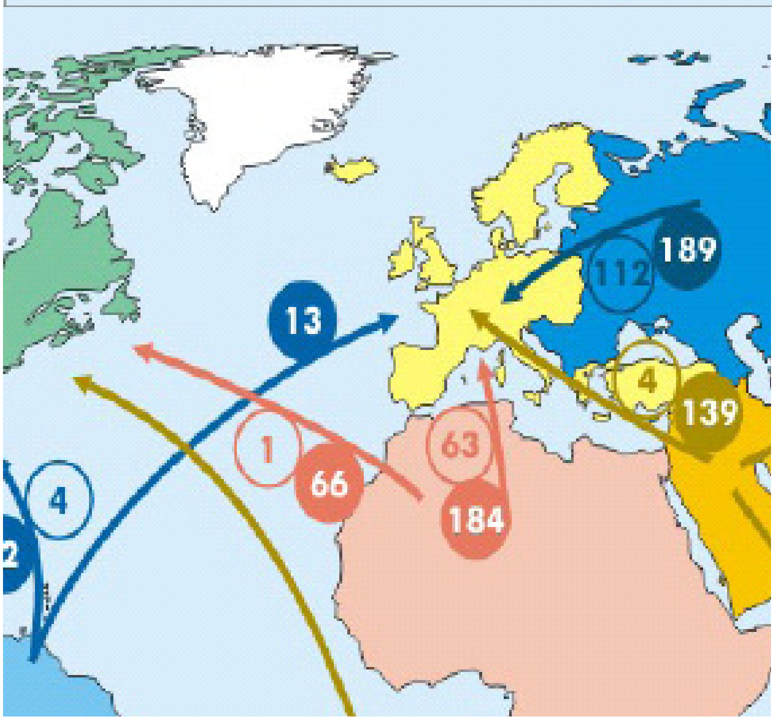
However, there are impediments for increased European imports from the Middle East, above all the political situation. Even though higher imports of gas from the Middle East will reduce Russia's, Norway's and Algeria's market share, and consequently their market power, it carries its own risk. This is particularly important regarding potential Iranian supplies because of the current dispute over its nuclear program.

Suppliers from other regions are also in the process of increasing supplies of LNG. Algeria and Nigeria are increasing production. Furthermore, several new suppliers to the Atlantic LNG market are expected to start production shortly. These include Equatorial Guinea (2008), Angola (2010), Norway (2007), Venezuela (2011), Iran (2011), Russia (2012-2015) and Yemen (2008).[58]

In the Barents Sea, the Snøhvit field is under development and is expected to come on stream in 2007.[59] It will produce LNG for both the American and the European market. In Europe it is expected to supply Spain with 1.6 bcm annually and France with 1.7 bcm annually through its French partners Gaz de France and Total.

[58] Hallouche (2006)
[59] Statoil.com





This map shows the intraregional trade flows of natural gas in bcm, as predicted by IEA in the World Energy Outlook 2004. It is worth noticing the large amounts of natural gas that is anticipated to be transported by LNG in 2030. One should also note how Middle East producers supply Asia, Europe and North America, and that the supplies are expected to experience an extreme growth. According to these projections, the Middle East is expected to be a very significant supplier to Europe. Africa is expected to triple exports for Europe and supply almost the same amount as Russia.

7.2.3. Competition from North America – long-term

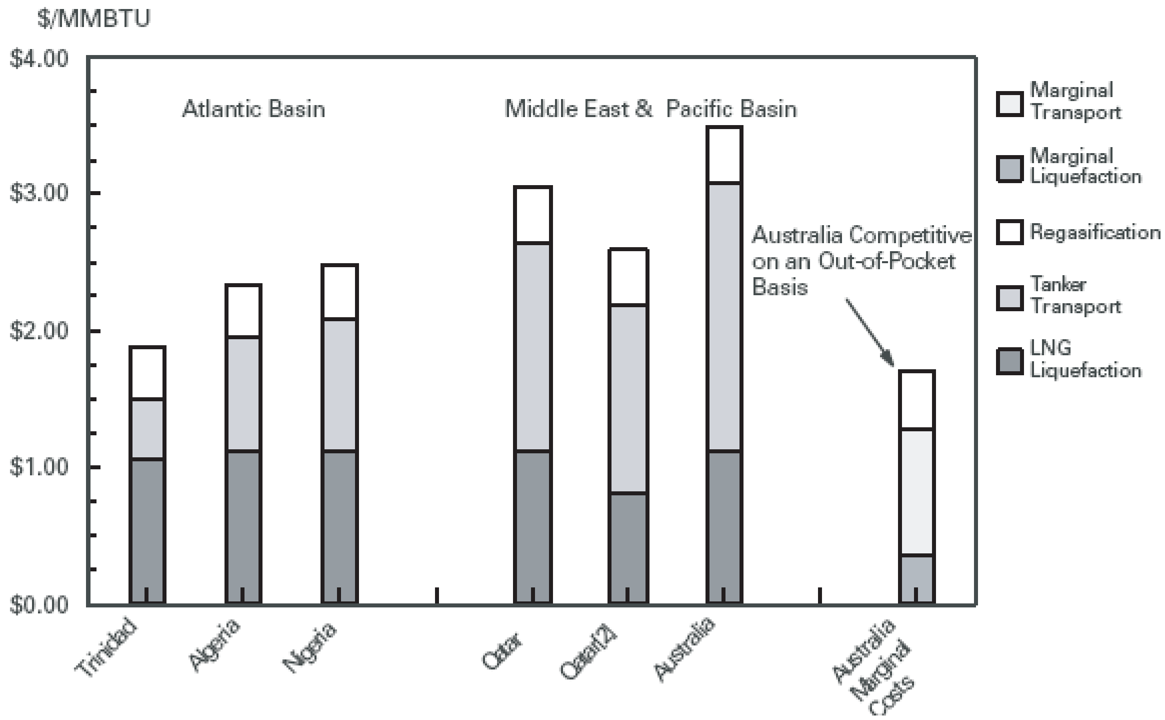
It is highly probable that US demand for gas imports will be higher in the next decade. The reason for this is the low R/P-ratio of approximately ten years (4.2) and rising demand for gas. As demand is increasing, the only way to maintain sufficient supplies is by increasing imports, as long as new large discoveries are not made. Canada will not be able to supply North America with sufficient amounts of gas by pipeline, so LNG import is the most probable solution to the future gas deficit of North America.

Declining shipping costs due to technological progress and economies of scale may make it economically feasible to transport LNG from the Middle East, North-Western Russia and West Africa to the American East coast. The question for Europe is whether North America, and particularly the US, will be able to attract a large part of LNG-production and thereby reduce LNG-supplies to Europe.

Because most of the current and potential LNG-supplies to the Atlantic basin are located closer to Europe than to the US, the price in the US will need to be higher than the price in Europe to compensate for higher transportation costs.

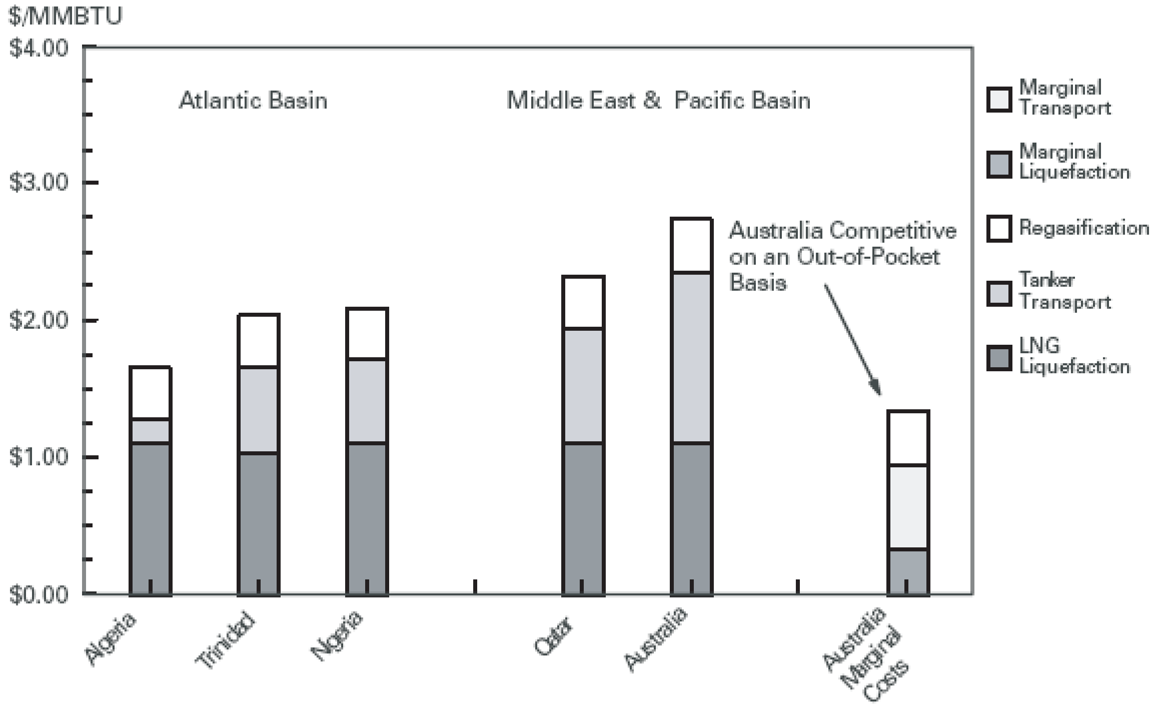
New projects will be more likely to destine the LNG for the American market than for the European market only if the price is assumed to be sufficiently much higher in the US than in Europe to make up for the higher cost of transporting the LNG to the US instead of Europe.

I will present an analysis and estimate by James Jensen (2006) of Oxford Institute for Energy Studies. He uses an expansion of an existing LNG-plant as point of departure, and estimates total costs for different producers supplying the US Gulf and Spain.



(Jensen 2006)

The figure above shows the costs of supplying a US Gulf terminal. Estimates include costs from liquefaction, transport by standard 138,000cm tankers and regasification for expansion with 3.3MMT trains. Qatar [2] assumes 7.5MMT trains and 200,000cm tankers, and shows the economies of scale in the LNG value chain. Marginal costs of Australian LNG are included to show the competitiveness of surplus LNG even from distant sources. This will be examined in detail in the next section.



(Jensen 2006)

The figure above shows the costs of supplying a Spanish terminal, with the same assumptions as in the figure on the last page.

A comparison of the costs to the US and to Spain reveals a cost differential of approximately $0.8 for supplies from the Middle East and $0.5 from West Africa.

The conclusion from the analysis is that it shows a significant, but not inhibiting cost differential between supplying the US and Spain. The cost differential between the US and Northern Europe (e.g. UK and Belgium) will be less. Still, Europe has a cost advantage over the US in attracting new LNG supplies.

The financial and political power of the US may however lead to a situation where the US will obtain a large share of LNG from the Middle East, Russia and West Africa, reducing Europe's share. It seems clear from most of the articles I have studied, and from the interviews with analysts, that North America will drive LNG development and be able to attract a significant portion of new LNG supplies, even though it is situated further away from most of the potential new LNG-sources than Europe is. However, the analysis above indicate that Europe has a substantial cost advantage over North America and should be able to attract a significant portion of new LNG production.

Long-term LNG-contracts are more than pure business contracts with profitability maximization as the goal. They are often the result of bilateral agreements between countries and issues like international relations, politics and security of supply will influence the decision of who to supply.

There are strong signals that North America and particularly the US will take a leading role in the Atlantic LNG market. As of July 2006 there were 5 reception terminals in North America and 45 proposed ones. Half of these had received federal regulatory approval and 7 were in the last planning stage or under construction. The total capacity of these seven projects and the existing ones would be 140 bcm/year, compared to US LNG imports of 18 bcm/year in 2005. [60] The latter number is expected to rise to 80 bcm in 2015 and 125 bcm in 2030, according to EIA.[61] The North American importers are likely to be serious competitors for the LNG available in the Atlantic Basin.

7.2.4. Competition from North America – short-term

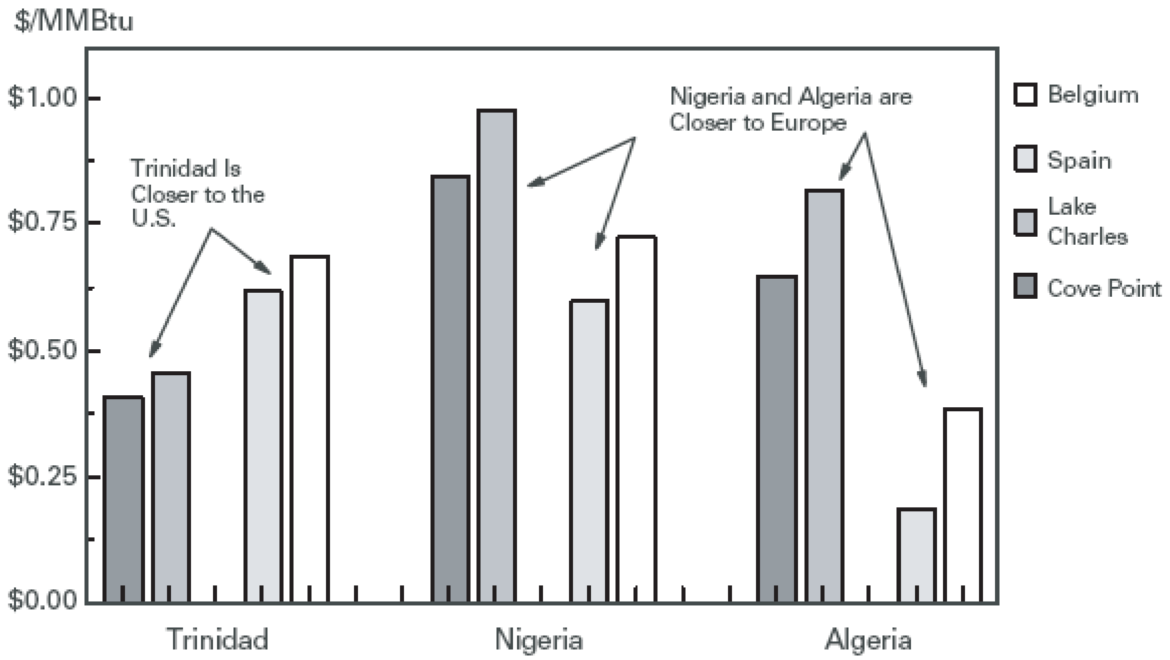
In the shorter term, a marginal cost / marginal income argument is more relevant. Supplies may be diverted if there are volumes that are free of any contractual obligations. The spot price differential will then be evaluated against the marginal cost of increasing the transport distance. If the price in the US is higher than the added costs of shipping the gas to the US instead of Europe, the gas will be diverted.

When considering the necessary price differentials for diverting supplies on a marginal cost basis, the results get very different from the results in the analyses in the last section. Obviously, a smaller price premium is needed in the US to make it profitable to ship the gas to the US than to Europe on a marginal cost basis than on a full cost recovery basis. The supplier will need a price premium that is high enough to cover the increased costs of making the longer voyage to the US instead of to Europe.

Jensen has calculated that it is necessary with a $0.53 higher price in the US Gulf than in Spain to provide the same result for an exporter in The Middle East.[62] The equivalent for the US instead of Belgium would be $0.21.

[60] Stern (2006)
[61] EIA (2006)
[62] The calculation assumes the shipping to the US is done by a 200,000cm tanker, while all other shipments are done by standard tankers. If using a standard vessel on the leg to the US, the necessary price difference would have to be $0.14/MMBtu

There is a tendency for higher prices in the US than in Europe, but the size of this difference varies. Moreover, the prices paid for LNG are often kept secret and are difficult to find. The future LNG prices are hard to predict, and it is therefore difficult to conclude on whether the US or Europe will win the battle over the volumes in the short term LNG-market. Still, it is worth noticing that the price differential needed for the US to attract supplies is relatively small compared to the differences between the American and European gas prices the last five years.



(Jensen 2006)

This figure shows tanker transportation costs from Trinidad, Nigeria and Algeria to Belgium, Spain and USA (East Coast and Gulf), assuming 138,000cm tankers. Trinidad is the only current producer that is situated closer to the US than to Europe, and consequently the only producer that will rather sell free volumes of LNG to the US than to Europe if the prices are equal.

The conclusion is that higher prices in the US than in Europe will divert a portion of the, by now, relatively small amounts of short term traded LNG to the US instead of to Europe. This will be the case as long as the price differential is larger than the cost differential from transporting the LNG to the US instead of to Europe. When comparing the price differential needed according to Jensen (2006) to the price differentials between the American and European gas markets found in section 4.5, I will conclude that the increased demand in the US relatively easily will produce a price differential of the required size.

7.2.5. Competition from other regions

Other regions may compete for new LNG-supplies from the Middle East. Japan and South Korea import large volumes of LNG, and increased demand may make them look to the Middle East for new resources. Indonesia, which is a major supplier to Japan and South Korea, is currently experiencing problems with even delivering the contracted volumes. Large contract volumes expire around 2010/2011 and Indonesia will probably not be able to renew these contracts.[63] Japan and South Korea have few substitution options and are financially strong. They might become competitors for LNG from the Middle East as the sailing distance from Qatar to Japan is approximately the same as the sailing distance to Belgium.

China is one of the most recent entrants in the LNG business. It had very ambitious plans in the early 2000s of constructing a large number of reception terminals, but after the oil price surge and consequent LNG price surge in 2004, the Chinese have scrapped many of the planned projects. Chinese importers are not able to compete on price with Japanese and South Korean importers. According to Stern, China had one terminal in operation, one under construction and nine under planning in October 2006. Chinese gas import policy appears to have shifted from LNG towards pipeline gas. The abundant gas reserves of Eastern Siberia are better suited for pipeline transport than LNG, and they have few other potential consumers within reachable distance. China will also start importing gas from Turkmenistan from 2009.[64]

Another country with the potential of becoming a large importer is India. It has two reception terminals, but has problems affording the LNG. There have been plans for large-scale gas imports from Iran. These projects seem unrealistic in the near future because of security issues. A potential pipeline has to transit through Pakistan, and energy projects, such as LNG imports, involving Iran will be incompatible with maintaining good relations with the US. However, India contracted large volumes of LNG from Iran in 2005 with supplies commencing in 2009, but it is unknown when or whether this supply will start.[65] LNG imports from Qatar could be feasible, but as the market is now, India cannot compete on price with Europe, USA and Japan / South Korea.

Jonathan Stern of the Oxford Centre for Energy Studies thinks that neither China nor India will become a serious competitor to Europe for natural gas. This contradicts the EIA who believes that

[63] Stern (2006)
[64] Stern (2006)
[65] The Hindu Business Line

China may import 70 bcm/year of LNG by 2015. However, from the recent development described above it seems clear that in the foreseeable future Japan and South Korea will be fiercer competitors to Europe than China and India will.

7.2.6. Predictions for indigenous supply

As of today, Britain is not anymore a net exporter and Clingendael International Energy assumes a substantial supply gap in 2010. The decline in British gas production and the subsequent supply gap will probably have to be alleviated by LNG from the Middle East and Russia.

Germany, Italy and Denmark also produce certain amounts of natural gas with 19.9, 12.0 and 10.4 bcm respectively in 2005.[66] The production from these countries is likely to decline in the coming years.

Norwegian production is expected to continue the increase until 2010. The anticipated increase is believed by EIA to approximately fill the supply gap caused by the decline in British production. According to the Norwegian Petroleum Directorate Norway exported 82.5 bcm in 2005, a figure which they expect to increase to 120 bcm towards 2010 and then remain stable until 2030. The new offshore gas pipeline "Langeled" will supply UK with 80 mcm of gas per day from the Ormen Lange field, which equals 29.2 bcm a year.[67]

IEA believes that OECD Europe production is to remain stable at 300 bcm until 2020 and then decline modestly to 276 bcm in 2030.[68]

[66] IEA (2006)
[67] Norwegian Ministry of Petroleum and Energy (2006)
[68] IEA (2006)

8. The impact on the market power of the gas suppliers

The impact on the market power of the current suppliers from the anticipated growth in LNG supplies will be treated in this chapter. Firstly, the degree of market power that they possess will be analyzed, using oligopoly theory. On the basis of these analyses and the analyses in the earlier chapters, conclusions will be drawn regarding the probable impact of LNG.

8.1. Characteristics of the supplies from Russia, Algeria and Norway

Currently, Europe is mainly supplied by Russia, Norway and Algeria. These exporting countries have been characterized by negotiating on a country-to-country basis, rather than letting the companies negotiate in the market. Moreover, the large production companies are usually fully or partly state-owned, for example Statoil, Hydro, Sonatrach and Gazprom.

In Norway, the production companies were organized in a Gas Negotiating Committee (Gassforhandlingsutvalget) whose objective was to maximize the price by price coordination and cartel formation. This committee has now been dissolved and the companies negotiate more independently with European buyers.

In Russia, state-owned Gazprom controls most of the production and all transportation. There have been talks of unbundling, but this does not seem likely at the moment, and Gazprom will probably remain the world's largest gas company. There are important independent producers as well, but these are not allowed to export, as Gazprom enjoys export monopoly.

In Algeria, Sonatrach is the state-owned company which controls most of the gas industry. Recently, some foreign companies like BP Amoco have gained access to investing in infrastructure, after a significant liberalization of energy legislation in 2005.

8.2. Market power

In this section I present theory on market power to be used to analyze the actual and potential market power of the current large suppliers and potential market power of new suppliers. I will first present the three sources of monopoly power to see whether it is useful to use these in order to determine the degree of monopoly power of the three large suppliers of natural gas to Europe. I will then discuss to what degree supplying natural gas to Europe is a natural monopoly. Finally, I will present oligopoly theory to be used to analyze the power of the current suppliers and the effects of potential new suppliers that will emerge as LNG becomes more widespread.

8.2.1. The three sources of monopoly power

According to Pindyck and Rubinfeld there are three sources of monopoly power: the elasticity of market demand; the number of suppliers and the interaction among suppliers.

The elasticity of market demand sets a lower limit for each supplier's demand elasticity. Because elastic demand reduces the ability for the supplier to increase prices, high demand elasticity will reduce the supplier's power, even if it is a sole supplier. This has implications for cartels. In markets with relatively inelastic demand there are large potential gains from organizing a cartel. An example is the oil market and OPEC's power over oil prices in the 70's. In markets with more elastic demand, like the coffee market, cartelization is less profitable.

The demand elasticity in the gas market is fairly low in the short term. It is, however, not as inelastic as the elasticity of oil demand. In practice, there are no substitutes to oil products used for transportation, such as gasoline, in the short run. In household gas consumption, electricity is to a certain degree a substitute. In power generation, gas fired power stations constitute a relatively small part of total generating capacity with a total of 14 % of total generated electricity in Europe in 2003.[69] Although the gas suppliers enjoy a relatively inelastic demand, it is not as elastic as oil demand.

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[69] IEA (2006)

The more suppliers of a certain size, the more difficult it will be for one of them to increase prices. With three main suppliers of gas to Europe there should be limited potential for any of them to raise prices considerably. This assumes, however, that the others have spare capacity. This is probably not the case in the short run, but may be in the longer run if the price rises to a point where it is profitable to exploit new gas fields or re-open old ones. To conclude, the fact that there are only three major suppliers can make it possible for one of them, especially Russia, to use a limited degree of market power. This will change if the new LNG-suppliers manage to get substantial market shares.

If the suppliers compete aggressively with each other they will have little monopoly power. They can not only refrain from aggressive competition, but also co-operate. This can happen either by an official agreement, like the OPEC cartel, or by tacit collusion. Of the three sources of monopoly power, the last one is probably the most relevant and important in the market for gas supplies to Europe. In 8.3 I will discuss whether Algeria, Russia and Norway exploit this source of monopoly power and whether other gas suppliers are trying to get monopoly power by forming a cartel.

8.2.2. European gas supplies as a natural monopoly

The definition of a natural monopoly is a situation where "one supplier can produce the entire output of the market at a cost lower than what it would be if there were several suppliers".[70]

This is usually the product of strong economies of scale. In gas supply there are strong economies of scale up to a certain point. In exploration and exploitation there are some economies of scale. There are economies of scale when constructing pipelines up to a certain diameter, and there are economies of scale in LNG as it is less costly per train to build two LNG trains than to build only one.

However, the strongest reason why the market for gas to Europe has the traits of a natural oligopoly is because it is natural in the sense that only a few producers were blessed with having gas reserves that were economically possible to exploit, and transport, to Europe at an economically feasible cost.

[70] Pindyck and Rubinfeld

Transporting gas to Europe from other major sources than Norway, Russia and Algeria by pipeline is costly and in many cases impossible because of geopolitical issues like the need for transiting conflict areas. Large-scale LNG transportation has been associated with too large investments and too high risks to be a viable alternative. These conditions have made the market for gas imports to Europe a natural oligopoly.

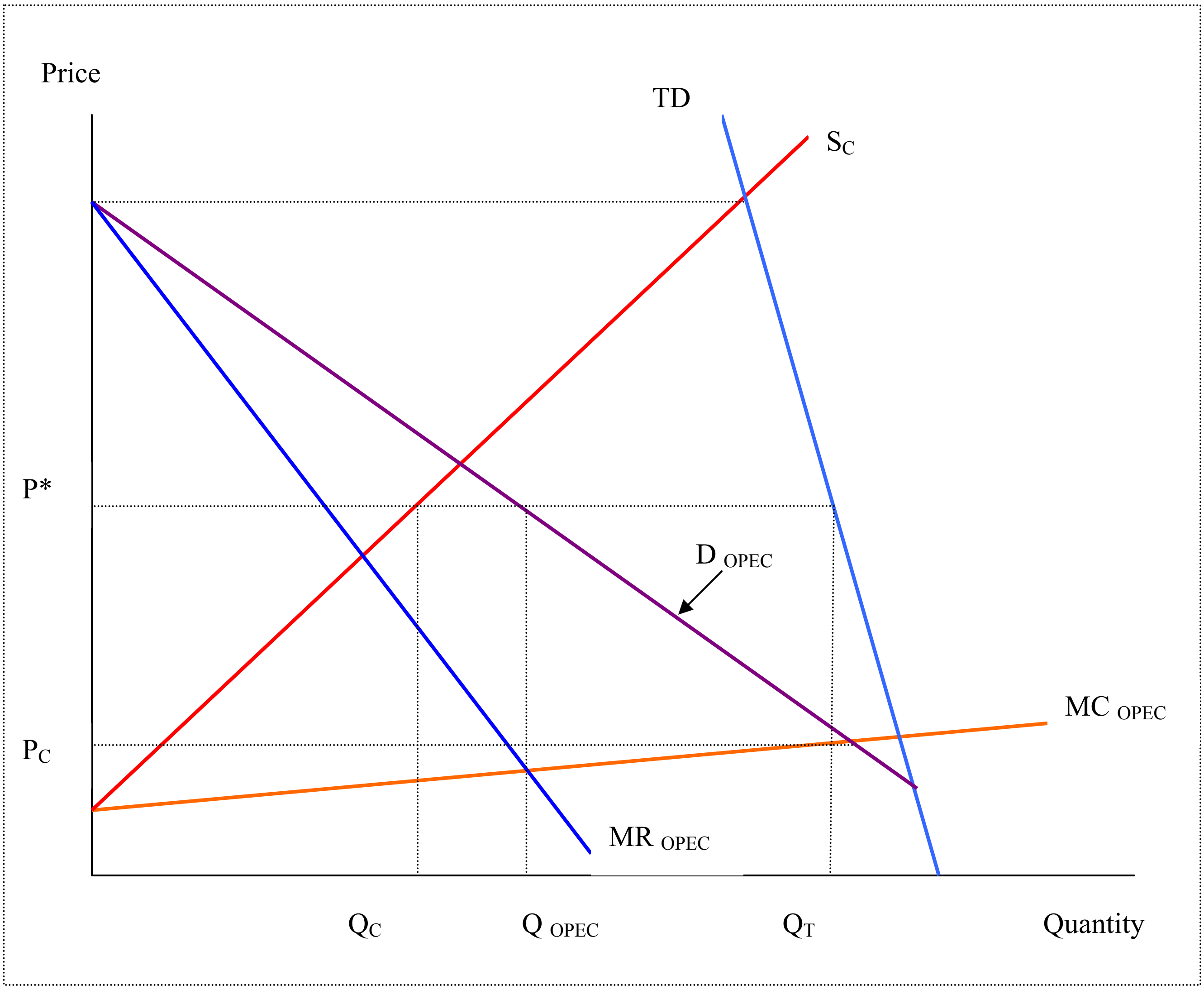
LNG has the possibility of reducing or removing the last of the two reasons for a natural oligopoly. Because of the decreasing costs in the LNG value chain, more producers may supply Europe and may supply large enough volumes to reduce the current supplier's market power. Increased use of LNG will reduce risks. Together with cost reductions this will reduce the major entry barrier in the market for supplying Europe with gas.

8.2.3. Cartel theory

In order to gain monopoly power producers may organize a cartel in which they co-operate about what volumes they will offer or what price they will set. If a sufficient amount of total volume is organized in the cartel and market demand is sufficiently inelastic, the cartel will be able to control the volume offered and prices. A relevant example of this is to be found in the oil market where OPEC was able to control parts of the total output and thus the price for several years. However, after the oil price shocks of 1973 and 1979 importers began to find ways of substituting oil and thereby reducing OPEC's power. There are also several examples of markets where cartels have not been able to control the market, even though they have controlled substantial parts of total output.

According to Pindyck and Rubinfeld there are two conditions for cartel success. The first is that the suppliers must create a stable organization that is able to agree on volumes and prices, and that is able to make the members adhere to these restrictions. The latter is challenging as each supplier will have an incentive to supply larger volumes than agreed upon in order to get a cartel price on larger volumes. The threat that such behaviour eventually will drive prices back towards free market equilibrium will be the only reason for cartel members to stick to the production quotas. For this condition to hold, a relatively small number of suppliers must control a significant share of total output and prevent new suppliers from entering the market. The second condition is the potential for monopoly power, which means that the market demand needs to be sufficiently inelastic. If demand is highly elastic, there will be little potential for higher profits from organizing.

One can show how a cartel can obtain high prices in a market with inelastic demand by using the oil market and OPEC as an example. The figure below shows how OPEC has been able to increase the oil price by using its market power.



TD is aggregated world demand for oil, S_c is the competitive supply curve. The difference between these is OPEC's demand curve, D_{OPEC}. This is inelastic because TD and S_c are inelastic. The profit maximizing quantity for OPEC, Q_{OPEC}, is found at the intersection of its marginal revenue and marginal cost curves. The corresponding price is P*. Without the OPEC cartel, the price would have been P_c, derived from the intersection of OPEC's demand and marginal cost curves.

8.3. Do Russia, Algeria and Norway have and exert market power?

Western Europe (excluding Norway) imports 35% of the natural gas it consumes and as mentioned earlier in this paper, the import dependence is set to increase further over the coming years. With a joint share of 88.6% of Western European gas imports, it is easy to see the possibility of Russia, Algeria and Norway exerting market power in the European gas market.[71]

From theory of monopoly power one would believe that it would be tempting for the three suppliers to co-operate on price and volume either by tacit collusion or by forming a cartel. As mentioned earlier, the three countries have formed national monopolies within each country as to gain market power. However, there have not been clear signs of any attempts of cartelization between these national monopolies, Gazprom, Sonatrach and The Norwegian Gas Negotiating Committee.[72]

Two interesting questions will then be why these countries have not been co-operating and if it is probable that they will start co-operating in the future. For Norway's part, a too visible co-operation with Russia and Algeria would be damaging for Norway's good relationship with the EU and a violation of the EEA agreement. As ESA, the competition monitoring body of the EU, managed to dissolve the Norwegian Gas Negotiating Committee, it will certainly not accept a price/volume-cooperation with Russia. Furthermore, it would not be consistent with Norway's foreign policy as a NATO-member, a membership which is crucial for Norway as a small, resource-rich country bordering Russia. Energy supply is tightly linked to national security, and a cartel-like cooperation between Norway and Russia, with the intention of exploiting Norway's NATO-allies in Europe, would not be in Norway's overall best interest. I will therefore conclude that it would not be beneficial for Norway to join a gas cartel and practically impossible because of the tight relationship with the EU.

The alternative is a cartel between Russia and Algeria. Currently, the two suppliers are not competing against each other directly in some parts of the European market. These markets can be split in Germany, Belgium and the Netherlands where Russia supplies substantial volumes and Algeria supplies nothing, and the Iberian Peninsula where Algeria supplies by both pipeline and LNG while Russia does not yet supply. However, in France and Italy, Algeria and Russia supply

[71] Appendix 11.3
[72] The Gas Negotiating Committee has been dissolved, but Norsk Hydro and Statoil remain large, partly state-owned players

approximately equal parts.[73] In these two countries there may therefore be potential gains in co-operating. Moreover, there may be potential gains from co-operation in the other parts of Europe because of certain interconnectivity between the European countries. This varies widely between the countries however, for example the Iberian Peninsula has poor grid capacity to the rest of Europe and the competition between Russian and Algerian gas is therefore weak in this region.

According to Gas Analyst Emmanuel Soetaert, Algeria, Norway and Russia do not act like a cartel, but the situation is best characterized as an oligopoly. He argues that it is hard to prove any exertion of market power.

As the dominant supplier to Europe, Russia has some market power alone. This market power may increase as some analysts believe that much of Europe's gas supply gap will be covered by Russian piped gas, e.g. by the new pipeline under the Baltic Sea to Germany. Although the European Commission is working for diversification, several of the big energy companies in Europe are entering into new long-term agreements with Gazprom. Both E.ON Ruhrgas, GdF and ENI have recently signed large contracts with the Russians.[74] These deals, together with the construction of the new pipeline in the Baltic Sea, indicate that Russia will increase exports to Europe. This is opposed by Tractebel Electricity and Gas International, which expects no increase in Russian gas supply to Europe the next decade.[75]

One might imagine a global gas cartel, after the OPEC model. The creation of the Gas Exporting Countries Forum has spiked new worries over this possibility, and this will be treated in the next section.

[73] Appendix 11.3 and 11.4
[74] Dagens Næringsliv, May 2007
[75] Tractebel (2002)

A factor restraining the market power of Russia, Algeria and Norway is that the EU has some market power on the buyer's side. Although gas contracts are bilateral, the EU has a coordinated strong focus on energy supply. Moreover, certain member states are very large consumers. For instance, Germany is an important market for Russia, and Spain is an important market for Algeria. In countries which are not crucially dependent upon a single supplier, the buyer may also use its market power against suppliers. This happened in 1981 when the US forbade importers to receive Algerian LNG because Sonatrach attempted to increase prices.

As natural gas is substitutable, especially in the longer term, the importing countries have a certain degree of market power. Although the European gas market today is a seller's market, there is competition from other fuels, especially in power generation, which leads to less market power in the longer term for the dominant gas exporters

8.4. Potential forms of impact on the market

Increasing LNG-imports may influence the market power of the current suppliers in two ways, through increased flexibility and by adding a significant volume.

If one builds a pipeline from Russia to Belgium, the supplier will forever be Russia. If one builds an LNG reception terminal in Belgium, it may choose to import LNG from different and also distant sources. The reception terminal may also be expanded and start to import from other sources than those initially selected. Even though the reception terminal does not add large volumes to the market, it adds flexibility.

As discussed earlier in this thesis, LNG may have the potential of supplying large volumes because of technological progress and economies of scale. IEA (2006) is predicting that Europe will be importing very substantial volumes of LNG by 2015. If new suppliers are able to gain a significant market share in the European gas market by supplying LNG, this will reduce the current suppliers' shares and consequently their market power.

8.5. Impact on the market power of Russia, Algeria and Norway

LNG will increase flexibility in the market. As the LNG market develops with more terminals, more sources and shorter and more flexible contracts, buyers will have the possibility of switching some portion, although small, of their imported volumes to other suppliers. Flexibility will act like a partial safeguard against shortages, but without large volumes there are few reasons to believe that this low-volume flexibility will have a significant influence on the market power of the current suppliers. As the marginal costs of piped gas are low once the pipe is laid, European countries will continue to import high volumes from Norway and Russia. The market power of Algeria is more sensitive to increased flexibility as 1/3 of Algerian gas exports to Europe are as LNG.

LNG will increase its market share of the total gas supply to Europe and total gas volumes delivered as LNG will increase. Large volumes of LNG from new suppliers will lower Russia's, Algeria's and Norway's market shares. Algeria may be able to maintain its share due to increasing exports both by pipeline and LNG.

An increasing number of LNG-producers will theoretically give more upstream competition, thus weakening the position of the current three large suppliers. However, as noted in section 4, European indigenous production is declining and if the LNG from new suppliers only is able to make up for this decline, the market shares of the current suppliers will remain the same.

The most important issue for Europe will be whether Russia will be able to maintain or increase its market power. As discussed earlier in this thesis there is little potential for new pipeline supplies and the LNG from Shtokman seems to be bound for the US. The increase in the use of LNG will therefore only have the potential of decreasing Russia’s market power.

8.6. Potential market power of new suppliers

More suppliers should give more upstream competition and less market power for any single producer. However, this can be avoided by the suppliers by forming a cartel like OPEC or by tacit collusion.

In 2001, several gas exporting countries set up an organisation called the Gas Exporting Countries Forum (GEFC). The organisation was established at a time of over-supply of natural gas and it was supposed to be a forum in which the exporters could discuss technology, trade and pricing. The creation of this forum raised concerns in many importing countries over the possibility that it might become a gas-OPEC, behaving like a cartel and restricting production in order to increase the gas price. OPEC was not able to control the oil price in the long term, but it had strong control in the short term, as it exercised in 1973 in protest of the Yom Kippur war. OPEC is today believed to have only limited, or no, control of the oil price, as it currently organizes a smaller part of total oil production than earlier. If OPEC was to regain power over the oil price, it would simultaneously gain some control over gas prices as well because gas contracts are formally linked to the oil price.

There are fewer gas producers than oil producers in the world, so coordination should be less difficult among the gas producers than among the oil producers. On the other hand, natural gas is easier to substitute than oil products because the latter is close to impossible to substitute in the short and medium term as fuel for vehicles.

Current members of GEFC include Trinidad and Tobago, Venezuela, Brunei, Indonesia, Malaysia, Iran, Oman, Qatar, the United Arab Emirates, Algeria, Nigeria, Egypt and Libya. In addition, Norway attends the meetings as an observer. Venezuela is not yet exporting gas, but has aspirations of starting to. The forum has invited importing countries to become members, but no such countries have yet accepted the invitation.[76] Currently there are probably too many members with diverging views for a cartel to be effective.

The focus of GEFC is reportedly shifting towards LNG. Most of the important LNG-exporters of the world are members of the forum, and the GEFC members provide 90% of the world's LNG exports. However, the potential for price coordination is currently low because LNG makes up only a small fraction of total energy use and it is relatively uncomplicated to substitute LNG by piped gas, oil and other fuels.

[76] Hallouche (2006)

At the moment GEFC is characterized by significant uncertainty regarding its future role, goals and even existence. It does not have any formal ties to OPEC. Thus it seems unlikely that it will turn into a cartel in the coming years. This may change if the gas and LNG markets enter a period of over-supply and a subsequent price decrease. It may also happen that some GEFC members form sub-groups in order to try to obtain market power by coordination. One such group might be Algeria, Iran and Qatar which have been the driving countries in GEFC and which are all OPEC-members. By now they have a relatively small market share, but this may change if Qatar continues its ambitious LNG development and Iran initiates one.

Recently, the fears of a Gas OPEC have been renewed because of recent statements by Russian officials. Iran has been trying to persuade Russia to participate in coordinating gas exports, and it is assumed that Venezuela, Algeria and Qatar are interested in closer coordination. The Russian president, Vladimir Putin, has stated that the idea of a gas-OPEC is interesting, and the head of Gazprom was among the participants at GEFC's meeting in Qatar in April 2007.

As a conclusion, there are currently few concrete signs of GEFC developing into a gas-OPEC soon, but there is a process going on which has the potential of leading to a gas-OPEC if or when the gas market makes this favourable for the most powerful suppliers.

The conclusion that the chances of a formal gas cartel, like OPEC is for oil, are relatively small in the current situation may change rapidly in the case of serious over-supply. A potential gas cartel may get a strong position in the LNG market, as there are relatively few LNG suppliers that have a large combined market share and the GEFC members currently supply 90% of the world’s LNG.

As shown in 8.2.3 a cartel can gain substantial market power in a market with inelastic supply and demand. The short-run gas supply will be inelastic and the short-run demand will also be inelastic, although probably not as inelastic as the demand for oil. The reason for this is that gas is easier to substitute than oil products, especially gasoline. Gas demand is inelastic enough, however, to make the analysis from section 8.2.3 relevant for the gas market. Thus, the potential power of a gas cartel can be strong, and a serious threat to the European importers. However, this conclusion will only be valid in the short or medium term. The reason is that gas has several substitutes and in the long term the market will regain balance, like the oil market has done after OPEC lost much of its power in the eighties.

9. Conclusions

European indigenous gas production is declining. Few new discoveries are made, with a consequent decline in reserves, and EU25 now holds only 1.4% of total known gas resources. With the current production level, EU25 will have consumed its reserves in 13 years, without new discoveries. The large gas reservoirs are to be found in the Middle East, Russia and Africa. These facts all make a strong case for stronger import dependency in Europe over the coming years, an import dependency which is already high.

The high, and growing, import dependence is a great concern for several European countries. Today, Western Europe's three largest import sources, Russia, Norway and Algeria, account for 89% of total imports. This is a concern for two reasons. Firstly, security of supply will be more difficult to ensure when there are few alternative sources. Secondly, the exporters may gain substantial market power.

The need for new gas supplies stems not only from decreasing production, but also from firm increase in demand. Natural gas is becoming more profitable as a fuel for electricity generation. Gas fired power plants produce twice the electricity per ton of CO_2 emitted compared to coal fired plants. The CO_2-quota scheme imposes substantial costs on generating electricity from coal instead of gas. Moreover, gas fired plants are more flexible with regards to adjusting production to electricity prices and can thus charge a higher average price than inflexible production like nuclear and coal. Increasingly, gas is used for direct household consumption.

Assuming no large discoveries are made in the North Sea, the decrease in production and growth in demand will lead to a significant increase in imports. Some of this might be supplied by pipeline from Norway and Russia, but by far not enough to cover the supply gap. This supply gap can be covered by gas transported by either pipeline or in the form of LNG, Liquefied Natural Gas. Given the anticipated substantial increase in gas demand, LNG will be of crucial importance in order to balance the market.

The LNG value chain requires large investments and LNG is only profitable compared to pipeline on long distances and/or in small volumes. In addition, LNG is far more flexible as it is possible to change supplier or receiver without making the entire investment over again. Flexibility is being enhanced by new market mechanisms and more short-term volumes in the market.

Technological progress has made LNG competitive with pipelines on increasingly shorter distances, and many of the potential new gas sources are situated relatively far from Europe, e.g. Nigeria, Qatar, Oman and Trinidad and Tobago. Furthermore, LNG transportation can be done in international waters and need not cross several borders and conflict areas, which is often a problem with pipelines. The formal analysis has shown that import restrictions on low-costs suppliers like Russia, and in the case of Spain; Algeria, have significant impact on the supply mix. Security of supply considerations will benefit the use of LNG in Europe.

The risks are high in LNG projects, so there will probably not be over-capacity in reception terminals. However, the market recognises the advantages of LNG and heavy investments are being made in liquefaction, shipping and reception terminals. Spain, Italy, Belgium, France and the UK have large projects under way. Furthermore, LNG exporting countries are investing heavily in production capacity. Especially countries in the Middle East are expected to become significant suppliers.

Europe will face competition for new LNG supplies. Demand for gas and LNG is increasing sharply in the US and several reception terminals are under construction. Europe has a substantial cost advantage over the US because Europe is situated closer to potential major sources such as North and West Africa and the Middle East. However, the US possesses the financial and political strength to attract a substantial part of new supplies.

The final conclusion is that European consumption of LNG will increase strongly over the coming years. This consumption growth will be made possible by imports from the Middle East and Africa.

The increase in LNG imports from new suppliers will influence the market power of the current major suppliers.

Currently, Algeria, Russia and Norway supply almost 90% of Europe's gas imports. With the partial exception of Norway, they are characterized by having one large state-owned gas company that markets the gas by using bilateral agreements and long-term contracts.

The three major suppliers constitute an oligopoly, with a certain degree of oligopoly power. This oligopoly has characteristics of a natural oligopoly because they are the only suppliers that have been blessed with large gas resources within convenient distance of the European market. Decreasing LNG costs weaken this natural oligopoly.

Today, there is probably little direct coordination of prices and output between the suppliers. Still, the oligopoly situation enables them, in theory, to engage in tacit collusion. Whether they do that or not is hard to prove, but it is probable that they gain a certain oligopoly premium. This is not large, however, because of substitution possibilities between gas and fuel oil in the short term and between gas and coal and nuclear in the longer term.

The increased use of LNG will reduce the current suppliers' market power through two effects. More flexibility will increase substitution possibilities, but this will only have a minor effect on the market power. A more important effect will be that substantial volumes from new suppliers will decrease the market share of the current suppliers, and consequently their market power. This conclusion assumes that the new suppliers do not organize a cartel. A gas cartel like OPEC for oil does not seem likely at the moment, but this might change if prices and profitability slide.

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11. Appendices

11.1. Abbreviations

Btu = British thermal units (energy content)

Mmbtu = one million Btu’s

bcm = Billion Cubic Meters

tcm = Trillion Cubic Meters

Cm = Cubic Meters

Mtpa = Million ton per annum

11.2. European LNG reception terminals

Location	bcm/year Gas	1000cm lng Storage	Supplying countries	Shareholders	Start year
SPAIN					
Barcelona	10,5	160	Abu Dhabi, Algeria, Australia, Brunei, Libya, Nigeria, Oman, Qatar, Trinidad&Tobago	ENAGAS	1969
- expansion	4	150			2005
- expansion	1,3	150			
Sagunto (Valencia)	6,6	300	Qatar	Union Fenosa, Iberdrola, Endesa	2006
- expansion	4,8	300			
Reganosa		300	Algerie, Middle East	Union Fenosa, Sonatrach, Endesa	2007
Bilbao	7,4	300	Abu Dhabi, Algeria, Australia, Nigeria,Qatar,Trinidad&Tobago	Bahia de Bizkaia	2003
- expansion	3,5	150			
Cartagena	7,9	287	Abu Dhabi, Algeria, Australia, Brunei, Libya, Nigeria, Oman, Qatar, Trinidad&Tobago	ENAGAS	1989
- expansion	1,3	150			2007
Huelva	7,9	310	Abu Dhabi, Algeria, Australia, Brunei, Libya, Nigeria	ENAGAS	1988
- expansion	2,9	150			2007
El Ferrol (Mugardos)	3,6	300	Algerie	Regasificadora de noroeste	2006
ITALY					
Isola di porto levante	8	152	Qatar	QP, exxon, edison	2008
La Spezia	3,9	100	Algeria	GNL, SNAM, ENEL	1971
- expansion					2007
Edison LNG - rivigo	8	250		QP, exxon, edison	2007
- expansion					
Brindisi	8	320	Egypt	BG	2010
- expansion	8	320			2012
Livorno	3			Edison, Solvay, BP	2007
San ferdinando	6-12			Falck	
Livorno offshore	3,6				2008
PORTUGAL					
Sines	5,5	240	Nigeria	Galp Energia	2003
- expansion	3	140			2007
NETHERLANDS					
Lion Gas	6	495		4gas	2009
Maasvlakte	6				2010
GREECE					
Revithoussa	2,3	130	Algeria	DEPA	2000
- expansion	4,2				2007
GERMANY					
Wilhelmshaven	10			E.on	2010
BELGIUM					
Zeebrugge	4,5	261	Algeria until 2007	Fluxys LNG	1987
- expansion	4,5	140	Qatar from 2007	1987 expansion 2007	2007
FRANCE					
Fos Cavaou	8,25	330	Egypt	Gdf	2007
- expansion					
Fos-sur-Mer	4,5	150	Algeria	Gdf	1972
Montoir-de-Bretagne	10,2	360	Algeria,Nigeria, Oman, Abu Dhabi, Qatar	Gdf	1982
- expansion					
Le verdon	2-3			Total	2010
UK					
South hook LNG	10,5	460	Qatar	qp, exxon	2008
- expansion	10,5	310			2010
Dragon LNG	6	336	Trinidad&Tobago, Egypt	bg, petronas, petroplus	2007
- expansion	3	168			
Isle of Grain	4,9	200	Algeria	Grain LNG	2005
- expansion	4,7	570			2008
Canvey island	5,4	240			2010

Various sources, mainly King and Spalding (2006)

11.3. European gas trade flows - pipeline

Pipeline	Bcm										
									ONLY TRANSIT		
To/From	Russia	Norway	Netherlands	Algeria	Germany	UK	Denmark	Libya	Belgium	other	SUM
Austria	6,8	0,78			1,1						8,68
Belgium	0,3	8,5	7,95		1,2	0,97					18,92
Finland	4,2										4,2
France	11,5	14,2	8,3		0,1	0,2			1,9		36,2
Germany	36,54	26,3	21,3			3,08	2,28			Ucraine 1,2	89,5
Ireland	0					3,05					3,05
italy	23,33	6,9	8	25,23	2,5	0,54		4,49			70,99
netherlands	2,97	6,16			4,5	1,82	2,13				17,58
Portugal	0			2,62							2,62
Spain	0	2,1		9,49							11,59
Sweden	0				0,15		0,88				1,03
Switzerland	0,37		0,9		1,2					0,37	2,84
UK	0	11,55	0,3		1				1,8		14,65
											0
SUM	86,01	76,49	46,75	37,34	11,75	9,66	5,29	4,49	3,7	0,37	281,85
BP 2006								TOTAL PIPE IMPORTS FROM OUTSIDE EUROPE			127,84

11.4. European gas trade flows – LNG

LNG

To/From	Algeria	Nigeria	Egypt	Qatar	Oman	Libya	Trinidad	UEA	Malaysia	Australia	SUM
Belgium	2,9						0,08				2,98
France	7,5	4,2	1,05		0,08						12,83
italy	2,5										2,5
Portugal		1,58									1,58
Spain	5,19	5	3,53	4,56	1,65	0,87	0,5	0,31	0,16	0,08	21,85
UK	0,45						0,07				0,52
											0
SUM	18,54	10,78	4,58	4,56	1,73	0,87	0,65	0,31	0,16	0,08	42,26

	Russia	Norway	Algeria	Nigeria	Libya	Egypt	Qatar	Others		
TOTAL % OF IMPORT	34,9 %	31,0 %	22,7 %	4,4 %	2,2 %	1,9 %	1,8 %	1,2 %	TOTAL	324,11
TOTAL IMPORT	246,59									
									Share of imports LNG	25 %
BP 2006									Share of imports pipe	75 %