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Natural Gas Pricing and Competitiveness

The impact of natural gas prices upon the industry's dynamics

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Natural Gas Pricing and Competitiveness

The impact of natural gas prices upon the industry's dynamics

It was witnessed a shale gas revolution in United States in the last few years that decreased gas prices at levels that offer the country an unforeseen competitive advantage. Shale gas might be a game changer in the United States' economy, driving the reindustrialization of the country. However, the impact of shale gas development in United States is much larger than its boarders: it changes the dynamics of the global industry.

In this context, the future evolution of the gas prices is of a crucial importance. Prices differences in the gas regional markets have created competitive advantages for gas based industries. Even if gas price is not the only driver of the industry's dynamics, it is an important factor and certainly it is the trigger for new investments. However, if a convergence in the gas prices will soon take place, the whole reindustrialization process in US is being overstated. Different studies on this issue have been preceded, but a clear, comprehensive and coherent view is still lacking. Then, this dissertation approaches two main controversial topics in the industry today: gas prices and their impact on the industry. It has the objective of (i) providing a global overview upon the gas pricing in all regional markets in the geopolitical context, (ii) developing a typology based on drivers and constrains for achieving a global gas price, (iii) analyzing the importance of gas price for the industrial competitiveness and (iv) assessing the actual impact of gas price on the industry's welfare.

The conclusions emerged from this study are that the gas price differences between the main regional markets will persist in the upcoming years, conferring thus an incentive to gas based industries to invest in US and profit of the cheaper gas. However, cheap gas is not the only condition for industrial competitiveness, even though it is an important element among many others. Therefore, very few countries present a high competitive advantage for the gas based industries, US being today the most important one. Nevertheless, the industry's dynamics cannot be explained by energy, even though it is one of the factors that heavily count in decision making process.

Key Words: shale gas, gas price, industrial competitiveness, industrial GDP, energy mix, global gas price, geopolitics, LNG;

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Abbreviations

BCM – Billion Cubic Meters

BEN – Brazilian Energy Balance

BIM – Bilateral Monopoly

CHP - Combined Heat and Power

CNG – Compressed Natural Gas

EIA – Energy Information Administration

FTA – Free Trade Agreement

GDP – Gross Domestic Product

GOG – Gas on Gas Competition

HH – Henry Hub

IEA – International Energy Agency

IGU – International Gas Union

LNG – Liquefied Natural Gas

LOP – Law of One Price

MMBtu – Million British Thermal Units

NBP – National Balancing Point

NET –Netback from Final Product

NGL – Natural Gas Liquids

NP – No Price

OPE – Oil Price Escalation

RBC – Below Cost Regulation

RCS – Cost of Service Regulation

RSP – Social and Political Regulation

TCF – Trillion Cubic Feet

UAE – United Arab Emirates

UK – United Kingdom

US – United States

Introductory Chapter

Since natural gas reserves and production are unevenly distributed on earth, geopolitics play an important role in the natural gas markets and, along with technological aspects, has always made gas pricing a very complex issue. Historically, different pricing mechanisms co-existed in different national or regional gas markets. This diversity can be mainly explained by some of the specific characteristics of the gas industry. The physical characteristics of natural gas, which create a strong dependence on pipeline transportation systems, have led to local markets for natural gas – in contrast to the global markets for oil. These local markets are characterized by different pricing mechanisms, different gas resource availability, political interests and technology developments. The emergence of LNG trade aims to link the regional markets, bringing them towards a more global approach. However, local markets still exist. The main players on the global level are North American Market as an important producer, few countries in South America, North Africa and Middle East as the biggest producers and exporters, Europe, as the Russian dependent market and Asia as the greatest LNG importer.

Nowadays, natural gas is finding its place at the heart of the energy discussion. The recent emergence of substantial new supplies of natural gas in the US, primarily as a result of the remarkable speed and scale of shale gas development, has increased awareness of natural gas as a key component of indigenous energy supply and has lowered prices well below recent expectations and well below prices in other regional markets. The price differences are creating competitive advantages to some markets, advantages that largely affect gas intensive industries' decisions.

Having a large utilization area, being an important energy source and a main raw material in many industries, natural gas is a valuable resource that can influence, to some extent, the welfare of a country. Competitive natural gas markets are, therefore, a key factor for many industries. It is commonly known that gas intensive industries often move to more competitive gas markets. Before 2008, the gas prices in most important markets were generally coupled at around 10 to 12 $/MMBtu. As they were following the same trend, no substantial arbitrage was under discussion. However, since 2008, prices decoupled, today's US gas price being of 3.7$/MMBtu, Europe's gas price at around 10$/MMBtu and Asia having the greatest gas price of around 16$/MMBtu. The decoupled prices today have changed the industry's dynamics and the arbitrage opportunities between markets.

The questions of how great is the impact of gas prices upon industry's growth, and whether the industrial competitiveness declared in US today is overstated represent the main motivations for this thesis. There are contradictory opinions on the future evolution of gas prices worldwide and on its importance for industry's dynamics. The advent of shale gas in the US has brought back the discussion of gas pricing schemes and the role gas can play in leading industrial development in many countries. Is shale gas a game changer or is its importance simply overstated in the context of industrial competitiveness?

Therefore, the objective of the thesis is twofold: it first provides an overview of the gas pricing mechanisms in different regional markets worldwide and their international industrial competitiveness. The focus is upon a very hot topic nowadays in the international gas market, raised by the shale gas boom in US and its cheap gas price. In face of the different pricing schemes available, the possibility of a re-convergence of gas prices and the role of shale gas in the US as a key factor in the future industrial competitiveness are discussed. Since these are questions with no direct answer, the approach will be to review the key drivers for the gas prices evolution and its implications on the industry's dynamics.

The thesis encompasses five chapters shared between two main parts: pricing and competitiveness. The first three chapters form one part, which treats the possibility of achieving a global gas price in the current market conditions. Second part of the thesis encompasses two chapters and addresses the question of the contribution of gas prices to the industrial competitiveness and the industry's dynamics. Each chapter is built as follows.

First chapter is a shortly theoretical introduction presenting the economic principles of price formation, the law of one price and price arbitrage between markets. These principles stand at the foundation of this thesis in the sense that, if enough arbitrage would exist in the gas markets and prices would have been converged, the discussion of industrial competitiveness and industry's dynamics caused by gas price wouldn't had its place today.

The second chapter aims to provide an overview upon the gas prices around the world, underling the regional character of gas markets and the geopolitics' contribution in it. Firstly, an overview on the different mechanisms used to shape the gas prices is provided. Each regional gas market is then presented through the perspective of its gas price formation and its own characteristic and particularities. North American market is currently under the shale gas effect, Europe is the battleground between the pipeline imports of Russian gas and new LNG suppliers and Asian market represents the largest

LNG market mainly supplied by the Middle East. The chapter provides a clear understanding on the regional gas prices, which is the context for the industry's dynamics.

The third chapter is dedicated to the future trends of the natural gas prices. Whether or not the prices are to converge again and how they will evolve in the short or long term, no one can tell for sure. However, as any other market, as long as arbitrage opportunities exist, there will be driving forces towards a global gas price. As gas is not a commodity like any other, the constraints towards a global market are greater and more difficult to overcome. The chapter aims to identify the main drivers and constraints towards the formation of a global gas market and a global gas price. Price evolution is driven by internal factors: price formation and market structure of each market, evolution of supply and demand, and also by external factors as LNG trade that facilitates arbitrage between markets and enables achieving a more uniform price by applying the law of one price.

The fourth chapter aims to analyze the industry's dynamics as a consequence of the natural gas market competitiveness. Starting from the importance of natural gas, especially in some industries, the chapter assesses the industrial competitiveness of the markets, taking into account three main criteria: gas price, gas availability and the political risk of the country. These criteria lead to the conclusion that US is nowadays the most appealing market for the gas intensive industries. This conclusion is to be sustained by the on-going process of re-industrialization in the US market, in which many manufactory companies are migrating to US to take advantage of the competitiveness, given by the low gas price.

In order to assess the actual impact of this competitive advantage upon the industry growth, two different case studies are to be analyzed in the fifth chapter: the impact of the natural gas price on the industry's dynamics in the United States and the impact of the lack of competitiveness of the natural gas market upon the industry's dynamics in Brazil. The data analysis will be preceded on the evolution of a few indicators: GDP by industrial sectors, energy mix, energy and gas intensity of the most representative industries and the gross output of these industries. The main conclusion emerged from analyzing these cases is that low gas prices are able to offer a competitive advantage for gas based industries in a global scenario, while local industry can be strong despite high gas prices.

The present thesis encompasses an ample analytical analysis of the natural gas pricing and industrial competitiveness, in a global context. Starting with the international pricing and geopolitics of the gas market, the analysis is then focused on the actual impact of natural gas prices upon the industry's dynamics. Firstly, a descriptive analysis is provided on the different price mechanisms used in each regional market, followed by a typology, based on the driving forces and constrains of achieving a global gas price. Future trends in natural gas prices are of a crucial importance for billion dollars decisions of many industry representatives. In this scope, a numerical analysis has been preceded on two countries with opposing situations of the gas market: United States and Brazil. The data analysis takes into account the evolution of a few indicators: GDP by industrial sectors, energy mix, energy and gas intensity of the most representative industries and the gross output of these industries, in order to assess the differences brought by two opposing natural gas prices in the manufacturing industry.

Besides analyzing academic papers, companies' studies, economic and energy newspapers articles and databases released by International Energy Agency and U.S. Energy Information Administration, I conducted face to face and telephonic discussions with representatives of significant Brazilian companies in the industry. Therefore the thesis takes into account the experts' opinions of ABRACE (Brazilian Association of Major Power Consumers and Free Consumers), and IHS and Gas Energy, two of the most important consultancy companies in the gas industry in the Brazilian market.

Part I Natural Gas Prices

First Chapter: Price formation and the law of one price

"Only Allah can set prices" – Mohamed

Introduction

This first chapter is a shortly theoretical introduction presenting the economic principles of law of one price and price arbitrage between markets. These principles stand at the foundation of this thesis in the sense that, if enough arbitrage would exist in the gas markets, and prices would have been converged, the discussion of industrial competitiveness and industry's dynamics caused by gas price wouldn't have its place today.

First section describes how prices are formed in the context of free market or governmental control. Second section introduces the concept of law of one price (LOP) and its arbitrage condition. Following, the LOP is discussed in the context of network industries, where the capacity of the link between markets is limited. Finally, the functioning of the LOP in the gas markets is approached, by giving some examples of the studies that have analyzed that. Nevertheless, the arbitrage between regional gas markets is not fully achieved, as low gas prices in some markets create an advantageous industrial competitiveness, which is highly debated nowadays.

1.1. Price formation

As a definition, price is a value that will purchase a good or a service and forms the basis of commercial transactions. In a free, liberalized market, prices are determined by the interplay of supply and demand. Conversely, when markets are limited by natural monopolies or vertical integrated industries, or when following some specific interests, prices can be controlled by the government.

In a free market, demand, supply, cost and price are interrelated. If the demand increases, consumers will be willing to pay more, raising thus the profit margins of the producers. In turn, this will incentivize producers to invest more and will attract new producers. The increased supply will tend to reduce the price of the product, reducing the profit margin as well. The market price is reached when the perfect equilibrium between demand, output, cost of production and price is reached. Any change in one will affect the others.

As well as demand, supply, cost and price of a commodity are interrelated, so are the prices of all commodities connected to each other. When, in the process of producing one good, is also another good obtained, as a by-product, there is a production interrelation. Substitution relation is when the price of one good goes too high and, as a consequence, is substituted for a cheaper one. Connectivity of consumption appears when two goods are used together for the production of another good. In addition to these direct interconnectivities, there is an inescapable relation of all prices. For instance, if a commodity price goes high and their consumers are unwilling or unable to substitute to another, they will be forced to consume a little less of something else. A change in any price affects, to some extent, an indefinite number of other prices (Hazlitt, 2012).

In some cases, the prices are controlled by governments which tries to keep them up or down, according to their interest. Most frequently, the prices are kept up for commodities that constitute a principal item of export. The idea behind is to rise the income of domestic producers on the expense of foreign consumers. This is how Japan did once with silk, British Empire with natural rubber, as Brazil did it with coffee and United States with cotton and wheat.

Government effort to keep prices down occurs mainly for basic domestic products or for incentivizing an industry to grow. For some specific industries, that are natural monopolies, the government enforces regulatory prices to avoid the exercise of market power. Also, efforts to lower the prices or at least to keep them from rising occur in time of inflation.

1.2. The Law of One Price (LOP)

Price formation mechanism is important not only internally, for the well-functioning of the market, but also externally. If the markets are connected, the prices in one market have a great influence on the pricing and functioning of the other market. There is thus a tendency for prices in markets to converge and to reach an equilibrium point, at which the price of purchasing the good is the same in all markets. This concept is known in the as the "Law of one price". When law of one price holds, arbitrage opportunities are said to be fully exploited as there is no profitable strategy by which a trader can transact between two markets.

Cournot (1927) seemingly was the first to assert that the same commodities command the same prices. Tying this relationship to the market, he states "the market is the entire territory of which the parts are so united by the relations of unrestricted commerce that prices take the same level throughout with ease and rapidity." Marshall (1952), being more circumspect and more operational, says “the more nearly perfect a market is, the stronger the tendency for the same price to be paid for the same thing at the same time in all parts of the market” (Brazel, 2007).

It is important to mention that a trivial condition for the law of one price to work between markets is the arbitrage to be possible. The absence of price convergence when arbitrage is not possible does not conflict with any basic assumptions of economics. In the literature there are identified four practical implications of arbitrage that are often ignored:

- arbitrage is normally possible between retail markets as resale is normally possible;
- for arbitrage to operate, price differential must cover relevant transaction costs, especially the transportation costs;
- unlike arbitrage between financial assets, commodity arbitrage takes time;
- arbitrage is not possible for products that are not identical.

All cases that fail to support the law of one price fall, in fact, into one of these situations, where arbitrage is impossible (Pippenger& Phillips, 2007).

1.3. Law of one price in a network industry

As explained in the previous section, arbitrage can exert an influence on prices only if there is a path over which the commodity can flow to bring prices within arbitrage limits. If there is no link or if there are limits on the flow of the commodity over the link, the prices can move farther away from each other, especially in short time periods. The link problem appears most frequently in network industries, industries that are dependent on a specific network type in order to function. The outstanding examples are gas and electricity industries.

In these industries, the connection structure and capacity between markets highly influences arbitrage limits and the power of the law of one price. The arbitrage limits switch to their upper bound when there are bottlenecks on the flows, but, over time, if the flow on the path dissipates, the lower bund may be reached. There are few important features of prices in a network market, as follows:

- prices are not unique but lie in an equilibrium set bounded by arbitrage limits;
- the arbitrage bounds depend on the structure of the network - number and capacities of paths between points;

- the arbitrage limits depend on the flows in the paths of the network where arbitrage bounds can switch between upper and lower limits as the state of the flows in the network changes;
- because arbitrage bands change dynamically with flows in the network, arbitrage-free prices may exhibit time dependence in the transition of a new equilibrium (De Vany& Walls, 1996).

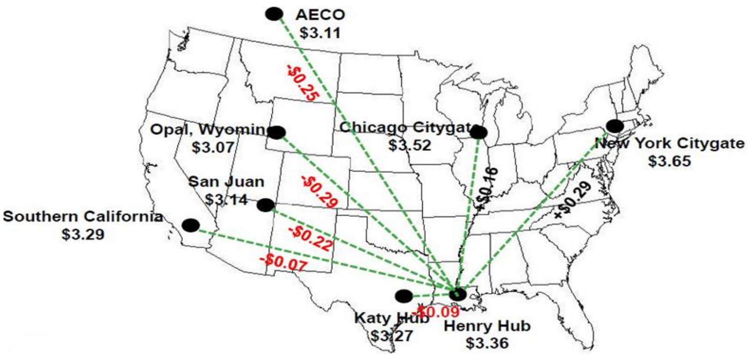
Basically, when law of one price in a network is rejected, is because there is no direct arbitrage paths between markets or because the paths between markets are capacity-constrained.

1.4. Law of one price in the gas industry

In many countries, mainly the most developed ones, the gas industries have been transformed from vertically integrated monopolies to more competitive structures. This has a direct impact as well on the price formation, which tends to switch from government controlled prices or prices indexed to competitive commodities towards a separate price mechanisms determined by the market forces of gas industry.

Different studies have been carried out on natural gas markets integration and price convergence as a consequence of market liberalization. When network is highly developed and markets are linked, arbitrage is possible and markets tend to converge to one price. Using cointegration analysis, Serletis (1997), and De Vany and Walls (1996) found that the opening of network access led to greater market integration as prices across different locations converged in the North American natural gas market. As Figure 1 shows, natural gas prices between the commercialization hubs in US don't differ with more than 0.3$/MMBtu, as a consequence of a developed and meshed transportation network that allows price arbitrage.

Figure 1: Natural Gas Prices at Commercialization Hubs in US (Oct 2010)

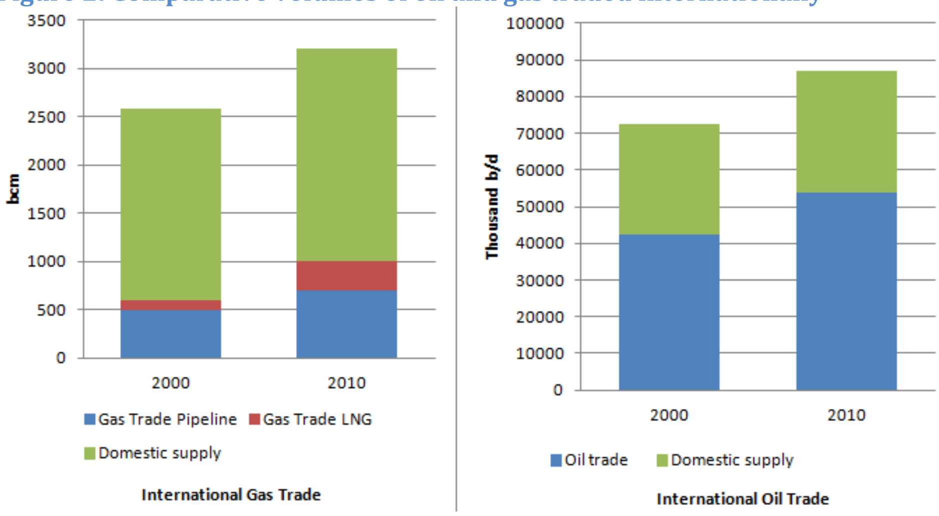


Source: EIA

In European context, Asche et al. (2002) shows an integrated gas market across France, Germany and Belgium, prices across regions following a similar pattern over time. Neumann et al. (2006) concludes that prices in UK (Natural Balance Point) and Belgian spot market (Zeebrugge) are fully converged, due to the Interconnector, the natural gas pipeline between UK and Belgium (Growitsch, Stronzik, & Nepal, 2012).

Nevertheless, one global price in gas industry will be achieved only when there will be enough transportation capacity between all the regional markets. Unlike oil market, gas market is essentially regional than a truly global market. This arises simply because gas suffers from the 'tyranny of distance', meaning that because it is high-volume, low-value commodity, it is expensive to transport. There are two means of transporting gas: pipelines and LNG. The gas trade, unlike oil trade, is mostly based on long term contracts. The reason lies in the cost structure of gas projects and their specificity, characterized by high fixed costs and relatively low variable costs. Therefore, the very high initial costs need to lock in future revenue streams to justify the project since the payback period is relatively long. This lack of flexibility resulted in much less gas being transported across international frontiers than is the case for oil.

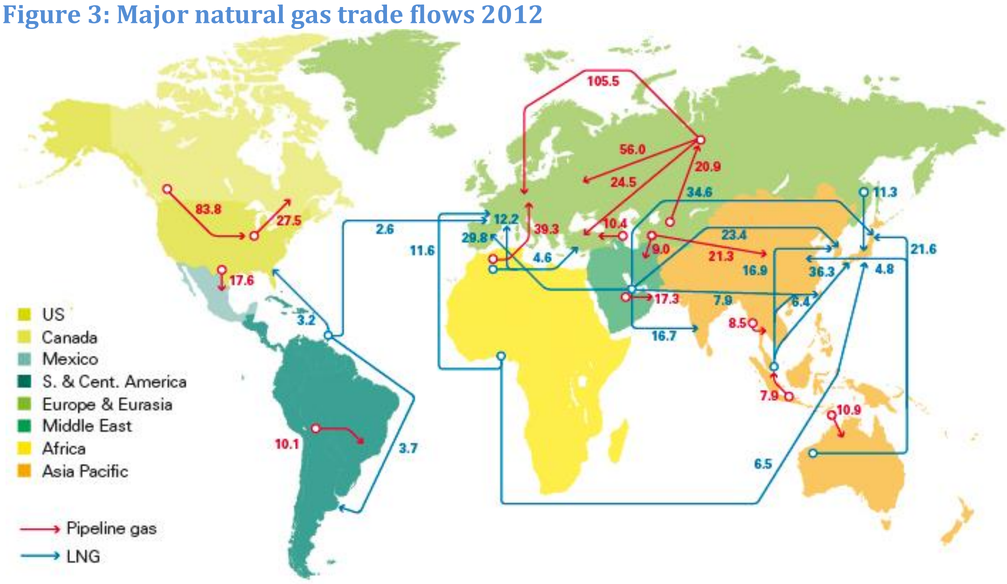
Figure 2: Comparative volumes of oil and gas traded internationally



Source: (Stevens, 2010)

In 2011, approximately 34% of natural gas consumption was internationally traded, from which 68% through pipelines and 32% via LNG. The regionally segmented markets in North America, Europe and Asia were pushed towards an "international gas market" through the development of liquefied natural gas (LNG) trade in the recent years. However, this trend may well have been halted by the sudden development of unconventional gas (Stevens, 2010). As trade between continents is still limited (Figure 3), the gas surplus resulted from shale reserves exploitation pushed prices in regional markets apart. There is not enough arbitrage among regional markets in order for law on one price to function and to achieve price homogenization.

Figure 3: Major natural gas trade flows 2012



Source: (BP, June 2013)

Few empirical studies show, however, an increased price convergence between continents. Using daily data for Henry Hub in US, NBP in UK and Zeebrugge in Continental Europe covering the period from January 1999 until May 2008, Neumann apply a time-variant coefficient estimation methodology and shows evidence of price converging towards the law of one price. As only importing facilities were located in the US and Europe, arbitrage is therefore limited to the diversion of cargoes from their original destination in either side of the Atlantic wherever prices are higher (Neumann, 2008).Since the increase in the domestic supply in US due to the discovery of non-conventional gas sources, the LNG imports are diverted from the US to Europe or Asia market, creating thus an arbitrage between the LNG import prices between them.

However, since 2008 the prices of regional gas markets decoupled, so that it cannot be yet discussed about a converged international energy market. The limited arbitrage possibility, the difference in the gas price formation mechanisms, the lately discoveries of non-conventional gas sources in US without the export possibility, are few factors that contribute to the great differences in gas prices around the world. Due to the high fixed costs of LNG facilities or pipelines, international trade is usually restricted by inflexible long term contracts. This, combined with new shale gas discoveries, resulted in a structural surplus of gas in US that decreased gas prices, creating thus an advantageous industrial competitiveness. The question is whether this gas surplus is an ongoing issue or new arbitration mechanisms will couple prices again.

Conclusion

Law of one price is an economic principle stating that when arbitrage between regional markets exists, the price differences of the commodities should only reflect the transportation costs (and other transaction costs) between the markets. Natural gas industry falls in the case of network industries, for which law of one price is not obvious, as arbitrage is more difficult reached.

The two main ways to transport gas is through pipelines and LNG. A well developed and meshed transportation network and the opening of network access have proved to result in greater market integration as prices across different locations converged in the North American natural gas market. In European context, an integrated gas market exists across France, Germany and Belgium, as prices across regions follows a similar pattern over time. Also prices in UK (Natural Balance Point) and Belgian spot market (Zeebrugge) are fully converged, due to the Interconnector, the natural gas pipeline between UK and Belgium.

However, there is very limited trade between the regional markets. From the total gas consumption, only 34% of it is currently internationally traded. Unlike oil, gas is a high volume and low value commodity that makes it difficult to transport, maintaining thus the regional characteristic of the market. In recent years, development of LNG market increased expectations that gas was moving from regional to more global markets but this trend may well have been halted by the sudden development of unconventional gas. As trade between continents is still limited, the gas surplus resulted from shale reserves exploitation pushed prices in regional markets apart.

Therefore, there are three main regional gas markets at the moment: US with a gas price of 3.7$/MMBtu, Europe with 10$/MMBtu and Asia with 15$/MMBtu. Prices weren't like this always, but since the shale gas exploitation arise in US in 2008, the surplus of gas combined with the low export possibilities decreased natural gas prices in this regional market. The question is whether this gas surplus is an ongoing issue or new arbitration mechanisms will couple prices again. This becomes even more relevant for gas based industries that are willing to take advantages of this price differences and increase their competitiveness on the global market. This study aims to analyze to what extent the gas price influence the dynamics of these industries and to identify the drivers and constrains for the LOP to function in this market.

Second Chapter: Gas Pricing in the International Market

> ***"Gas prices are noisy. The only constant is change." (Sightline Daily, 2009)***

Introduction

Gas prices have taken center stage in the global media in the last years. At the individual level, gas prices change involves just a change in the cost to fill up at gas station; in reality gas prices have a much greater impact, directly affecting the economy, political relations and to some extent, the world's industry dynamics.

This chapter aims to provide an overview upon the gas prices around the world and to explain how geopolitics influence gas markets. It provides the context for the industry's dynamics, the core subject of the thesis. First section explains the underlying principles of the gas price formation, followed by an overview on the different mechanisms used to shape the gas prices. Third section explains how these mechanisms are used around the world and in which percentages: it shows that generally, domestic consumed gas is priced differently than traded gas. Finally, for each regional gas market is presented the gas price formation in the view of its own characteristic and particularities. North American market is currently under the shale gas effect, Europe is the battleground between the pipeline imports of Russian gas and new LNG suppliers and Asian market represents the largest LNG market mainly supplied by the Middle East. Despite its huge potential and reserves, gas market in South America is quite underdeveloped, Trinidad and Tobago being the most important player on the trade market. This chapter underlines the regional character of the gas markets.

2.1. Gas Price Formation Principles

Gas pricing has always been a very complex issue. Historically, different pricing mechanisms co-existed in different national or regional gas markets. This diversity can be mainly explained by some of the specific characteristics of the gas industry. However, the economic logic behind the gas pricing has to follow, in general terms, two basic rules: it has to cover the production, transportation and distribution investments and it has to substitute in a competitive manner other energy sources already used or that could be used instead (Almeida & Ferraro, 2013).

First of all, it is worth mentioning the importance of the transportation costs, which is high, compared to other commodities. The gas transportation from the production place to the end user markets requires high investments in either pipeline systems or, in the case of LNG, in liquefaction, shipping and regasification facilities. Due to the strong asset specificity of the gas industry, the projects of getting gas from the source to the market are characterized by very high fixed costs and relatively low variable costs. Therefore, the very high initial cost needs to lock in future revenue streams to justify the project since the payback period is relatively long. Thus, gas trade highly depends on long term contracts or on keeping the vertical integrated utilities and create inflexibility in the gas commerce. The price formation of natural gas for a final consumer is dependent of the gas molecule price, as well as of the transportation and distribution cost, which can account for more than 50% of the final price. Moreover, the determination of the transportation and distribution tariff can vary from market to market.

Another characteristic that influence the tradability of gas and thus, its pricing, is the storage ability as an important source of flexibility. In gas industry, storage plays a much smaller role than in commodities as coffee, as it requires higher investments and in some cases relies also on the right geology to be available. This makes even more difficult for the balance between input and output (demand and supply) to be maintained, a necessary condition for the security of supply. However, short term fluctuations can be absorbed by line pack (IGU - International Gas Union, 2012).

The big difference in the contribution degree of gas in the national power generation mix is another salient characteristic that influence gas pricing. If the price of natural gas is above the prices of other substitute fuels, there is an incentive to replace gas in the power generation mix. Therefore, for every market there is a cap for the natural gas price. Historically, the commodity price maintained a direct link with oil price and its derivates.

Gas pricing is directly influenced by the maturity of the national market and by the degree of the liberalization. A growing liberalized market with a large international LNG trade results into a fast evolution of gas pricing. The tendency of this market is to switch from oil indexed pricing of long term contracts to a price determined by market forces. In different countries, short term markets and spot markets for natural gas are developing, so that gas price has daily quotation resulted from the competition of more suppliers.

2.2. Price Formation Mechanisms

There are multiple mechanisms that are used for determining the gas price. Since natural gas reserves and production are unevenly distributed on Earth, geopolitics play an important role in the natural gas markets and, along with technological aspects, has always made gas pricing a very complex issue (Yuri Yegorov, 2009). Historically, different pricing mechanisms co-existed in different national or regional gas markets. Looking from the perspective of the consuming country, there are three ways in which it can be supplied with gas: from domestic production, from imports through pipelines and from LNG imports. Therefore, a distinction is made between the domestic gas prices and export prices, where importing countries don't have much control on the gas price. Below there are the main price formation mechanism used by the countries that possess natural gas reserves for internal and external consumption (IGU - International Gas Union, 2012).

- Oil Price Escalation (OPE)

Under OPE mechanism, gas price is linked through a base price and an escalation clause to competing fuels, usually crude oil, gas oil and/or fuel oil.

- Gas-on-Gas Competition (GOG)

GOS mechanism determines the gas price by using market forces, the interplay of supply and demand. Trading take place at physical hubs (e.g. Henry Hub) or notional hubs (e.g. NPB in the UK) and thus, a short term fixed price basis is determined. Long term contracts that use gas price indices to determine the monthly price, for example, rather than competing fuel indices are also considered to be using GOG mechanism. Spot LNG is included, as well, in this category.

- Bilateral Monopoly (BIM)

Under BIM, the price is being fixed for a period of time by bilateral agreements between large entities, usually at the Government or state-owned company level.

- Netback from Final Product (NET)

Netback value methodology establish the gas price as the maximum price that the consumers are willing to pay, taking into account the price of the substitutes fuels. Hence, considering the disposition of the final consumer to pay for gas, the retail price is fixed. From it, by removing the distribution, transportation, storage costs and taxes, as well as the profit margin of the companies involved, the wholesale gas price is obtained. The NET methodology usually occurs when gas is used as a feedstock.

- Regulation: Cost of Service (RCS)

Under Cost of Service Regulation, the price of gas is determined by the regulatory authority so that the investment and operation costs to be recovered and a reasonable rate of return to be obtained.

- Regulation: Social and Political (RSP)

The price is set, on a irregular basis, on a political/ social basis, in response to the need to cover increasing costs or possibly as a revenue increasing exercise.

- Regulation: Below Cost (RBC)

The price is deliberated set below the costs of producing and transporting, often as a form of state subsidy to its population.

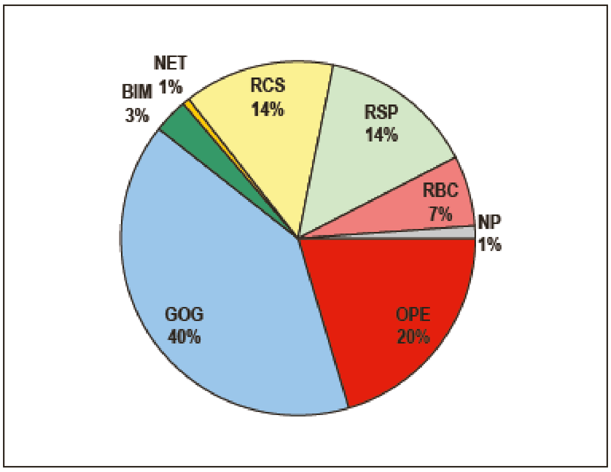
- No Price (NP)

Gas is offered for free.

2.3. Overview on the gas pricing mechanisms worldwide

A report released by International Gas Union in 2013 presents the situation on the wholesale gas price formation mechanism worldwide in 2012. According to that, 40% of the gas consumed is priced under gas on gas competition. This is both gas from indigenous production, manly in North America, and exported gas through pipelines and LNG. Oil price escalation is used for 23% of the gas, mainly for the exported gas. The regulated gas prices account for a third of the gas consumption worldwide and are used almost exclusively for domestic gas.

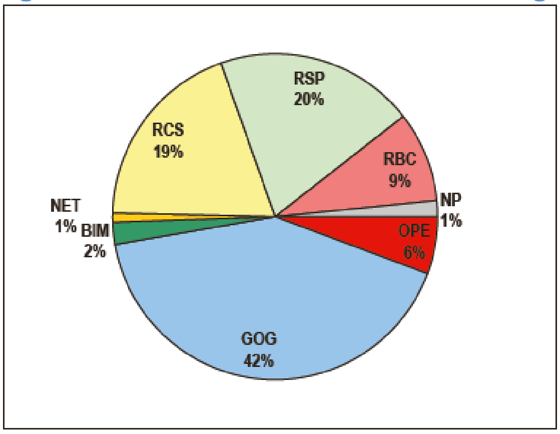
Figure 4 : World Price Formation Mechanism 2012



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

When considering only the gas consumed from indigenous production, the most used mechanism is gas on gas competition - in North America and UK especially. Regulated prices all together account for almost half of the domestic gas and is largely used in Former Soviet Union, Middle East, Asia and some countries in South America. Only 6% of gas is indexed on oil price, in Europe and Asia. The gas from indigenous production accounts for almost 72% of the world gas consumption.

Figure 5: World Price Formation 2010 - Indigenous Production

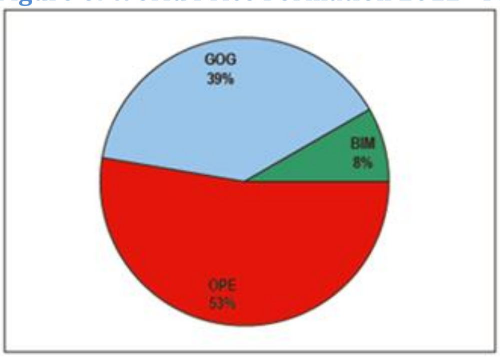


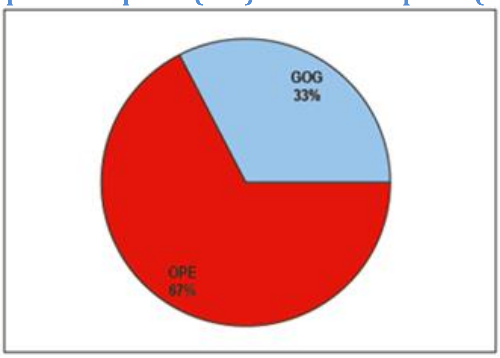
Source: IGU Report 2012 Wholesale Gas Formation Mechanism

Pipeline imports account for 19% of gas world consumption and 53% of it is priced under oil price escalation, mostly in Europe but also in the Former Soviet Union, especially Ukraine and Russia and a small contribution from China, Singapore and Thailand. GOG competition has a share of 39%, most of the gas being imported in Europe. BIM accounts for 8% of pipeline imported gas and is used in almost all of the Former Soviet Union and Middle East, largely from Russia to Belarus and from Qatar to UAE.

Most of the gas imported via LNG is also oil price escalated, largely dominated in Japan, Korea and Taiwan, Europe, mainly Spain, France and Italy, and China and India. Gas on Gas competition mechanism is used for imports into countries such UK, USA, Canada and Mexico, whose domestic market pricing is also GOG, and is also used for importing spot and short term priced LNG, especially Japan and Korea.

Figure 6: World Price Formation 2012 - Pipeline Imports (left) and LNG Imports (right)





Source: IGU Report 2012 Wholesale Gas Formation Mechanism

Important to mention is that in the same region there can be used different price formation mechanisms. Usually the domestic gas for internal consumption is priced differently than the imported gas, whose price formation is controlled by the country of origin (Ferraro, 2013).

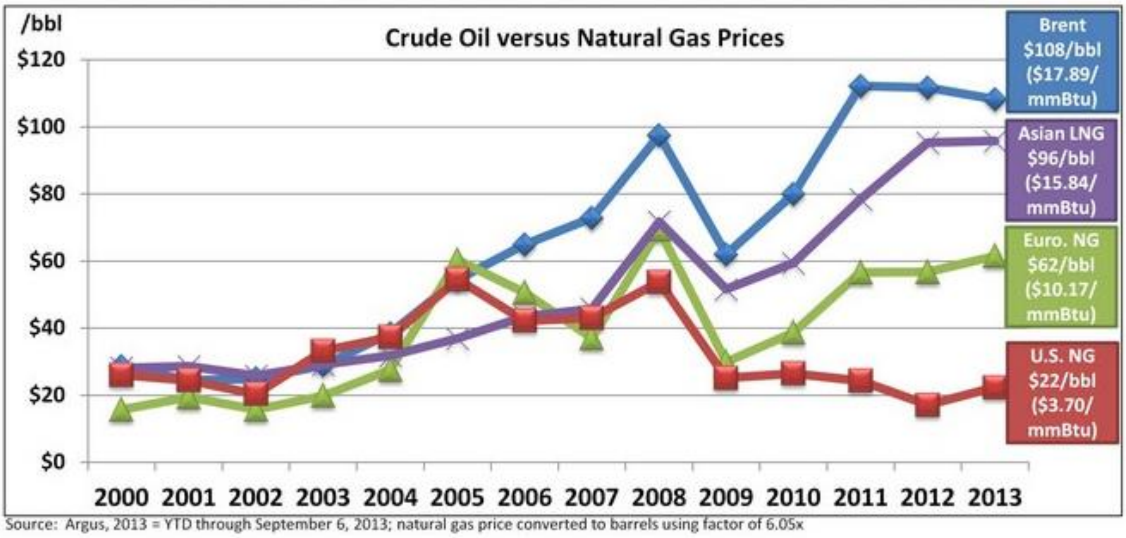
Given the variety of price formation mechanisms used worldwide, the uneven distribution of gas on earth, which gives advantages to some countries, the different economical and technological development, the prices of natural gas are very different around the world. In 2012, gas prices were varying between few cents, in the Middle East, up to US$17/MMBtu in Asia. This difference is more pronounced when it comes to domestic prices. In the case of LNG trade, the arbitrage is easier to reach keeping thus prices more homogenous.

2.4. Natural gas pricing in different markets and the geopolitical implications

The literature reviews the interaction between economics, politics and geography in the case of gas industry. The physical characteristics of natural gas, which create a strong dependence on pipeline transportation systems, have led to local markets for natural gas – in contrast to the global markets for oil. There are different market organizations for natural gas in different regions, especially in regard to the resources. Depletion of world gas resources makes delivery more costly and location more important, which leads to growing local monopoly power of some gas producers. At the same time, development of LNG technology and trade could make world markets more integrated and transform these regional markets into a more global one. However, the selection of paths of pipelines or LNG imports are tight related with geography, spatial density of discovered gas deposits and density of consumption around the world and, moreover, an important aspect is represented by political constrains. Therefore, economics theory must be complemented by geopolitics and technology in the case of natural gas industry (Yuri Yegorov, 2009).

Following, it will be explained the pricing mechanisms in different gas markets, emphasizing how is this related to geopolitics. Currently world gas trade is concentrated in three regional markets: North America; Europe –served by Russia and Africa; and Asia – with a link to the Middle East. There are significant movements of gas within each market but limited trade among them. Each have a different market structure resulting from the degree of market maturity, the sources of supply, the dependence on imports and other geographical and political factors. These regional markets set natural gas prices in different ways and due to the limited arbitrage between them, prices can differ substantially among regions, as it can be observed in Figure 7.

Figure 7: Regional natural gas prices and oil price



Source: Argus, 2013

2.4.1. North American Market – Henry Hub prices

North American gas market is clearly dominated by GOG pricing method, 98% of the gas consumed here being priced this way. The fully liquid trading markets in the USA are being a reference for pricing gas in Canada and Mexico, the markets directly linked to the USA market. The rest of 2% of gas consumed in the North American market is not priced, being used by Pemex in Mexico in refinery processes and for enhanced oil recovery.

United States gas market is the most mature market in the world, being the pioneers in the liberalization of natural gas industry. This process of liberalization resulted in a strong gas market and for the first time gas on gas competition is determining the gas price in the early 1990s. The robust spot market developed allows setting prices by the forces of supply and demand (IGU, 2013).

The trade takes place in physical hubs. In 2009 there were 33 active hubs in North America, of which 9 in Canada and 24 in United States. There are three types of hubs: production hubs, market hubs and commercialization centers. Production hubs are just interconnection points between two or more pipelines, whereas market hubs offer additionally storage services, ownership transfer and electronic commerce of gas. In addition of these, a commercialization center offer ancillary services (balance, dispatch and storage for balancing market). There are seven market hubs and 11 commercialization centers in USA.

The main commercialization center, Henry Hub, is the biggest in the world. It is placed in Louisiana, connects 12 pipelines and has three storage reservoirs. The price information given by the hub is used as reference point for contracts, in future markets and in derivatives markets of gas. The most known future market for gas is NYMEX, aimed to offer financial hedge services. In Henry Hub there are traded contracts for gas(molecule) to be delivered in one month and involves a daily fixed amount with the price established in the day the contract was signed. It can be considered the biggest gas spot market in the world. In general every molecule of gas is sold and resold 100 times before its actually physical delivery (churn rate = 100), fact that assures a high liquidity of the market.

Nowadays, the North American market is considered to be one of the most competitive markets in the world, given its low prices in comparison to other markets. Looking at the overall picture of the natural gas prices in US, Europe and Asia, it is noticeable that until 2008 prices were convergent. Starting with 2008, spot natural gas prices constantly decreased (US and UK), and decoupled from the long term contract prices based on oil escalation (Germany, Japan), mainly as a result of an abundant domestic supply. In US prices decreased in one year from more than \$12/MMBtu to around \$3/MMBtu, and remained constantly low until today, whereas spot prices of UK start increasing back to the level of Germany's oil escalation price.

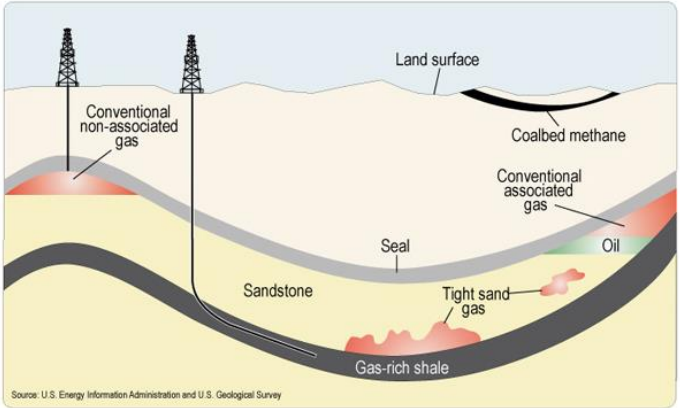
What keeps gas prices low in USA is the abundant domestic supply, the fall in demand due to the economic crisis and the export's limitation. The beginning of the crisis in 2008 coincides with the discovery of a non-conventional gas resource, the shale gas.

2.4.1.1. Shale Gas

Shale gas refers to natural gas that is trapped within shale rock formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce.

Hydraulic fracturing, commonly called "fracking", is the technique that enabled natural gas to be produced from shale in commercial quantities at economical costs. Water, chemicals, and sand are pumped into the well to unlock the hydrocarbons trapped in shale formations by opening cracks (fractures) in the rock and allowing natural gas to flow from the shale into the well. When used in conjunction with horizontal drilling, hydraulic fracturing enables gas producers to extract shale gas economically.

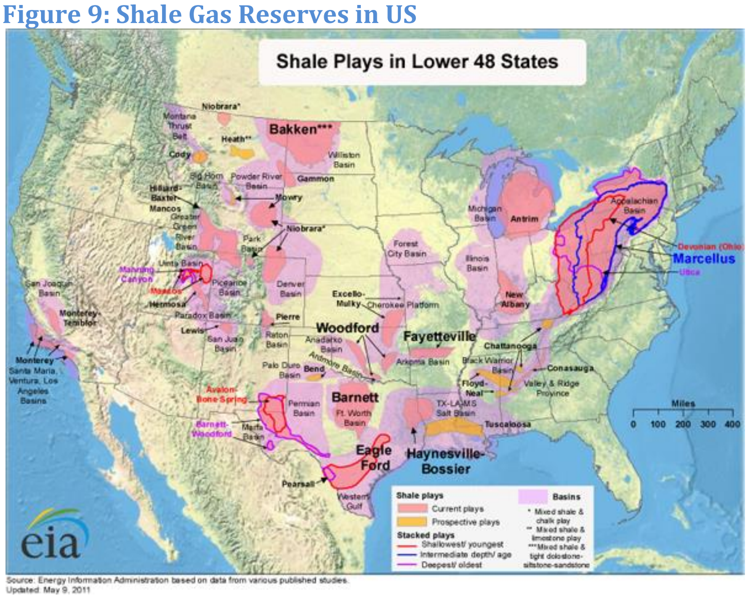
Figure 8: Schematic geology of natural gas resources



Source: (EIA, 2012);

Shale gas is found in shale "plays," which are shale formations containing significant accumulations of natural gas, which share similar geologic and geographic properties. Production in Barnett Shale play in Texas started in 2000 and the experience and information gained from developing it have improved the efficiency of shale gas development around the country. Therefore, in 2008 starts the shale gas production in another five plays, creating a supply excess. An important play today is the Marcellus Shale in the eastern United States.

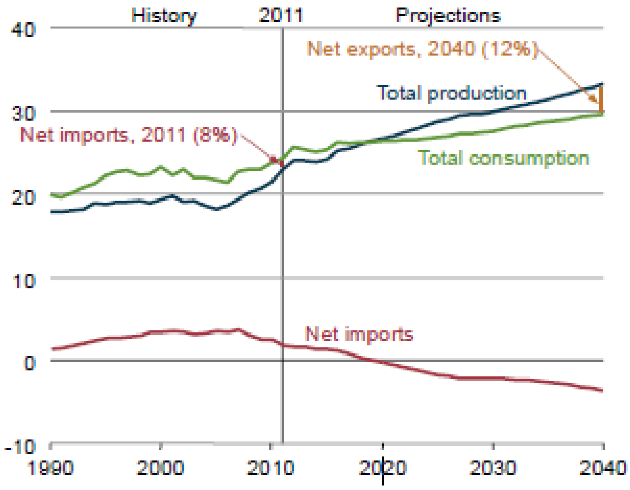
Figure 9: Shale Gas Reserves in US



Source: EIA

The increase in the indigenous production due to the exploitation of shale gas directly modified the dependency relations in the international market. Before 2008, USA was a country with an increasing gas dependency. Besides the pipeline imports from Canada, USA was importing LNG from Trinidad and Tobago, Nigeria, Algeria, Qatar and some others, having built LNG import capacity of almost 14 billion cubic feet per day. However, higher domestic production has made imports unnecessary, leaving existing import capacity mostly idle, while the long term contracts for imports have been redirected to Europe or Asia. According to US Energy Information Administration EIA study, the total production will exceed the internal consumption in 2020.

Figure 10: Natural Gas production, consumption and imports in US (trillion cubic meters)



Source: DOE/EIA Annual Energy Outlook 2013

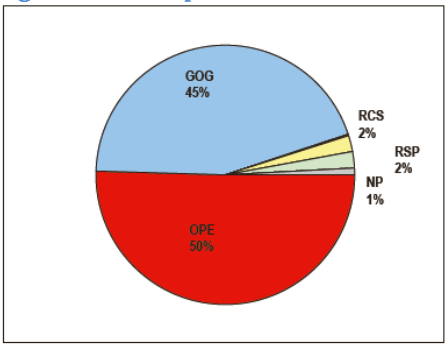
Therefore, beginning with 2012, the possibility of exporting gas was taken into consideration. This decision might change radically the geopolitics of natural gas in North America. USA has a number of projects in progress in regard to future LNG exports.

2.4.2. European Gas Market

European gas consumption in 2012 accounted for around 12% of total world consumption. European gas market can be easily divided in two: the spot market of UK, where the gas is priced under GOG competition and the continental European gas market, with around 40% of the gas being imported from Russian pipelines under OPE.

Therefore, the 45% of the GOG priced gas takes place in the UK but also in some northeast and central European countries, who are trying to diversify their gas supply portfolio and decrease the Russian gas dependency. The regulated prices are on the domestic production in Romania (RCS) and Poland, Hungary, Croatia and Bulgaria (RPS). The NP gas accounts for 4.5 bcm gas used in refineries and oil recovery in Norway.

Figure 11: Europe Price Formation 2012



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

2.4.2.1. The Spot Gas Market of UK

Nowadays, natural gas market in UK is the second most competitive market in the world, after the US market. The significant degree of competitiveness in the British market is given by the long process of transition from the British Gas monopoly to a liberalized model following the successful development of the oil reserves in the North Sea. The transition involved the privatization of British Gas, the establishment of the regulatory body OFGEM, the restrictions in the supply area upon British Gas, the open access to the transportation and distribution network from third parties and the emergence of the free consumer, able to choose his supplier on a free market. When the gas market became open for the residential customers as well, in 1998, the natural gas price in England was defined as entirely competitive and National Balancing Point -NBP was formed. NBP cannot be considered a physical hub, as the ones in North America, but a virtual hub in the transportation system created by regulatory means. The transactions in NBP take place between players that already have reserved capacity to inject or withdraw gas in the transportation system operated by Transco. As Transco adopts entry-exit tariffs, all agents can participate in the market, buyers being independent of the withdrawal point of gas and suppliers independent of the injection point. Therefore, NBP is the main commercialization center in UK, having a churn rate of 15. The natural gas prices are often indexed at NBP in England, especially in the future market of natural gas Intercontinental Exchange (ICE). In Europe, NBP is also becoming a reference hub price.

The spot prices in Henry Hub and NBP were following a similar trajectory until 2009, when they decoupled due to the great natural gas supply from non-conventional sources in US. This caused, in fact, a decouple between the Henry Hub price and the oil price, as UK spot gas market is connected to the oil escalation market, via arbitrage with the European market, whose supply is given mainly by the oil indexed long term contracts.

2.4.2.2. Continental European gas market "as the battleground"

The natural gas market in Europe also suffered the liberalization process, as a result of the market integration policies implemented by the European Union. This process of deregulation leads to a progressive modification in the commercialization form and gas pricing.

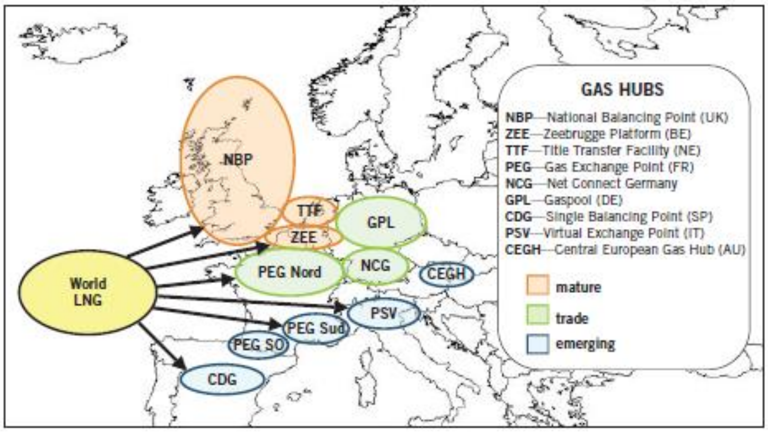
Unlike United States and UK market, the continental European gas industry is very concentrated. This high degree of concentration is explained, basically, by the fact that most of the European countries doesn't have gas resources and thus, are depended on imports (Almeida & Ferraro, 2013). Gas imported via pipelines in Europe comes from very few sources (Russia, Algeria and Norway) and is controlled by the state-owned companies. The supply concentration in Europe minimizes the negotiation possibilities for importing countries, as well as the importing gas is most of the time controlled by one company in each country. Therefore, the market is practically controlled by few huge companies, called national champions.

Natural gas wholesale pricing in Europe is facing two opposing ideologies, represented by the more traditional oil pricing escalation and gas on gas competition in the spot markets. Around 40% of the gas supply comes via pipelines from Russia and is bought under long term contracts linked to oil prices. These contracts are usually on a period of over 20 years and have a "take or pay" clause of 85%.

The high dependency on the Russian gas raises some questions for the Europe, in the sense that Russia might encounter difficulties in supplying much longer Europe due to the lack of investments in its upstream segment. Another problem is the monopoly of Gazprom upon the gas exports for the European importing countries. Moreover, the pipelines' pathway from Russia to Europe passes through Ukraine and Byelorussia, who takes advantage of their geography position in the geopolitical game of natural gas. In order to reduce the Russian gas dependency, some countries in Europe start importing LNG, mainly the one redirected from US since the shale gas boom. Also, new projects for building pipelines are developing, like the Nabucco project that links the gas producing countries from Middle East to consuming countries as Austria, Germany and Chez Republic, avoiding Russian territory, but through Turkey, Romania and Hungary (Almeida & Ferraro, 2013).

On the other hand, since the development of NBP in mid-1990s in UK, other hubs start emerging in the continental Europe. Still, their development is hindered either by the lack of supply liquidity or by obstacles to infrastructure liquidity at key transit points, such as border crossing within EU (Melling, 2010). However, NBP strongly influence the continental hubs thanks to its liquidity and to the construction of the two gas lines connecting the British market to continental Europe (Interconnector and Balgzand Bacton Line). Therefore, when spot gas prices are higher in continental Europe, there is an incentive for UK to export gas to the continent and the other way around (Almeida & Ferraro, 2013).

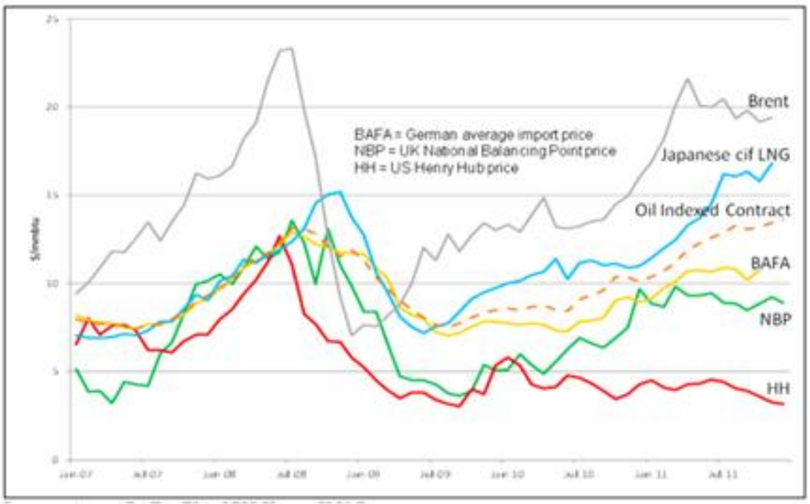
Figure 12: European Gas Hubs



Source: (Melling, 2010)

Thus, the NBP price and the price in other spot markets follow the trends of the oil price, which still dominates the European gas supply. This convergence tendency appears in the medium term because the long term contracts from Russia, Algeria and Norway have take-or-pay clauses of 85%. Therefore, if the spot prices are lower than the oil price, it is possible to diminish the imports and buy the 15% of needed gas in spot market. On the contrary, if the spot prices are higher, spot markets loose the demand share that would use take or pay clauses.

Figure 13: Global Gas and Brent Prices



Source: (Heather, 2012)

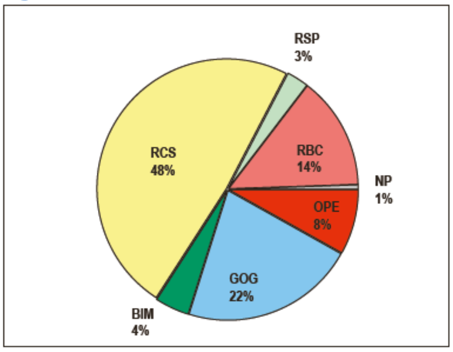
Figure 13 shows the evolution of the gas prices in the most representative markets. In Europe, the benchmark prices are the UK NBP hub price and the average price of all German gas imports (BAFA). As the graph shows, the Oil Indexed Contract prices and German border prices were very similar until 2009, as very little gas was imported into Germany other than at oil-linked levels. However, due to the fact that the long term contracts start being renegotiated as a consequence of the increasing difference in oil prices and gas spot prices and a spot price index was introduced, and due to the increasing in the LNG imports in Europe as a mean to diversify the portfolio, a gap opened between the two prices, BAFA prices falling with about 10-15% (Stern & Rogers, 2011).

LNG imports in Europe are also facing the two opposite pricing methodologies: traditional oil linkage, on one side, and market based prices, on the other side. Most of the LNG price imports received by the continental Europe are oil or gas oil linked. In North West Europe the LNG delivered price is the NBP hub price less the regasification cost of entry into the gas grid (~0.5$/MMBtu).A new type of LNG imports emerged in Europe once the shale gas production in US since 2008, namely the redirected LNG previously contracted by US and not needed anymore. These are indexed to Henry Hub, to which is added the liquefaction, regasification fee and the shipping cost.

The European markets are, therefore, more than ever characterized by the duality between oil-linked gas prices and spot prices in continental hubs, influenced by the NBP spot price. Even if most of the imported gas is priced under OPE, the transition to a gas on gas competition prices takes gradually place in continental Europe. From the share of 15% that GOG had in 2005 (and 78% of OPE), it reached in 2012 a share of 45%, whereas OPE declined to 50% (IGU, 2013).

2.4.3. Former Soviet Union Gas Market

Figure 14: Former Soviet Union Price Formation 2012



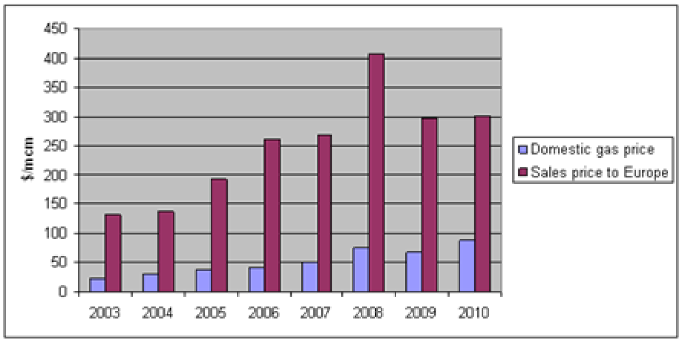
Source: IGU Report 2012 Wholesale Gas Formation Mechanism

Former Soviet Union consumption in 2012 accounted for 19% of total world consumption, with 65% of the gas being priced under regulatory methods. The domestic consumed gas is regulated in Russia and Azerbaijan (RCS), Kazakhstan, Turkmenistan and Uzbekistan (RBC) and Ukraine (RSP). The GOG competition occurs only for the eligible large consumers in Russia. OPE is used for pricing the gas imported through pipelines into Ukraine, Russia and Moldova, while BIM is used for the imports from Russia to Belarus.

2.4.3.1.Russian domestic gas prices

Russia plays an important role on the international gas market, being the main supplier of gas for Europe and the owner of the largest proven gas reserves in the world. Despite this, there are increasing worries about Russia's ability to continue to meet both rising domestic demand as well as export obligations. Russia has one of the highest domestic consumption rates per capita, 70% of the gas production being used internally. It uses two-tier pricing system for natural gas: one a low, regulated price for domestic consumers and one for its European exports.

Figure 15: Russian domestic gas price and sales price to Europe



Source: (Mozur, 2011)

Gazprom, the state own company, dominates the domestic market, producing 75% of Russia's gas and also enjoying monopoly over exports. Besides being a normal gas company, it pursues political goals too, being used by the president Vladimir Putin as a tool of foreign policy to consolidate his power. An example is the cutting off gas supplies to Georgia, Ukraine, Belarus and Moldova during political rows. In addition, Gazprom helped him also internally, as Russian home and industrial consumer have enjoyed generous subsidies for natural gas, thanks to the expensive gas sold in Europe (The Economist, 2013). The domestic gas prices in Russia were regulated below cost, to allow poor people to get warm during the cold winter, while the European gas market represented the only source of profits from Gazprom. The long term contracts of 20-25 years have been important for securing the large and irreversible investments. The shorter contracts and spot gas markets are not in the advantage of Russia also due to its limited technical flexibility, with modest storage capacity.

However, as Figure 15 shows, the domestic prices are following an ascending trend. The recent developments of European gas market such as liberalization and the surge in LNG capacity is putting pressure on long-term contracts to make them more flexible and of a shorter duration. Gas demand in Europe shrank following the global economic crisis and the increase of shale gas production in USA has made LNG suppliers look towards Europe (Gabriel, Moe, Rosendahl, & Tsygankova, 2010). Now Europe has the option of buying liquefied natural gas (LNG) that America no longer needs to import. Also the lack of investments and the need to invest in new expensive fields leaded to higher internally costs. All these factors prove that increasing domestic price was absolutely necessary. Due to the problems that Gazprom encountered lately, the Below Cost Regulation on the domestic market was changed to Cost of Service Regulation in 2008. Moreover, it was introduced the target of industrial gas prices reaching netback parity with the export prices in Europe by 2011. Even if the prices increased with around 15-27% between 2006 and 2011, they still remained far from netback parity due to the doubling of oil price, the target date for netback parity having been moved to 2015 (Henderson, 2011). The Russian government and Gazprom consider netback pricing a measure to increase domestic prices, secure investments into the Russian gas sector, stimulate reduction in domestic gas demand and thus obtain spare capacity for exports. However, very high domestic prices are not in the interest of Russia, both for social reason and with regard to the competitiveness of Russian gas-consuming industries. If a direct link between European and domestic prices is established, Russia's desire to increase gas prices in Europe may be reduced.

Even if the export netback parity is still a long way off, this doesn't mean that gas prices in Russia will stay at the low current levels. The evolution of gas pricing in Europe towards a more hub based model while the oil price is clearly moving to a new, much higher range, the emerge of significant new low-cost gas resources held by non-Gazprom producers, and the ongoing issues concerning regulation of the gas transport sector in Russia are some of the factors that drives domestic prices in Russia up.

2.4.7. African Gas Market

Africa is, on the global gas market, linked to the European market, being an important supplier. It accounted only for 3% of the gas consumption worldwide, but detains about

7.5% of the world's total reserves, especially in Egypt, Algeria, Nigeria and Libya. 86% of the domestic production is priced RBC.

However, the geographical distribution of African natural gas resources is going through a period of profound change as new discoveries have been recently made in East Africa, namely Tanzania and Mozambique. Based on initial estimates, 3400 – 4000 bcm of gas reserves have been discovered in offshore Mozambique and around 630 bcm in offshore Tanzania. Given this huge discoveries, LNG projects are already rapidly advancing both in Mozambique and Tanzania, with a major target-market: Asia (Hafner & Tagliapietra, 2013).

2.4.4. Asian LNG markets

Natural gas typically accounts for 10–20% of the energy mix in the Asia-Pacific economies, with China the major exception: only 4% of its energy needs are met by natural gas. The significance of natural gas trade to the Asia-Pacific economies is underscored by the fact that imports accounted for 37% of total natural gas use in the region in 2010.

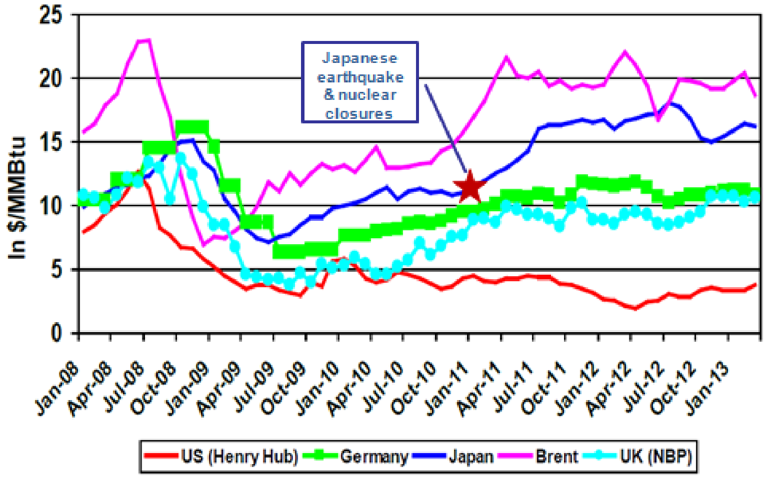
Asia is the largest LNG market, 64% of total LNG imports being towards Asia in 2011. The main LNG suppliers for Asia are Qatar, Egypt, Nigeria, Australia, Indonesia, Malaysia, Peru and Russia.

Natural gas demand in the Asia Pacific is expected to grow substantially in the next 10 years. In Japan, the LNG demand increased a lot since the earthquake in March 2011 that provoked the Fukushima nuclear disaster. Therefore, 50 of Japan's nuclear reactors have been shut down and oil and coal-fired thermal power stations were damaged. As Japan replaced its lost thermal and nuclear capacity by running all its gas-fired units, Japan's LNG demand has increased so that almost reached the maximum capacity of the import terminals and gas-fired power plants. In Korea, the government is planning to shut down nuclear plants and promote more gas utilization and renewables. Therefore, the LNG demand forecast is rising. Moreover, Taiwan LNG demand could be boosted if the start of the 4th nuclear plant is rejected in a referendum and the three operating plants are closed after 40 years. LNG demand is also expected to be strong in China, India and in the emerging markets in South East Asia (Doshi, 2013).

Japan experiences the most expensive gas price in the world. The Asian LNG market is imperfectly competitive — Asia–Pacific countries such as Japan and South Korea source their LNG imports from a limited number of countries which hold significant market power and can charge high prices. Moreover, the pricing formulas of most long-term Asian

LNG contracts tie natural gas prices to the price of crude oil, which has been high in recent years and has thus further contributed to Asian buyers paying the highest worldwide prices for natural gas.

Figure 16: Japanese gas prices in rapport to US, UK, German gas prices and Brent price



Source: (Timera Energy, 2013)

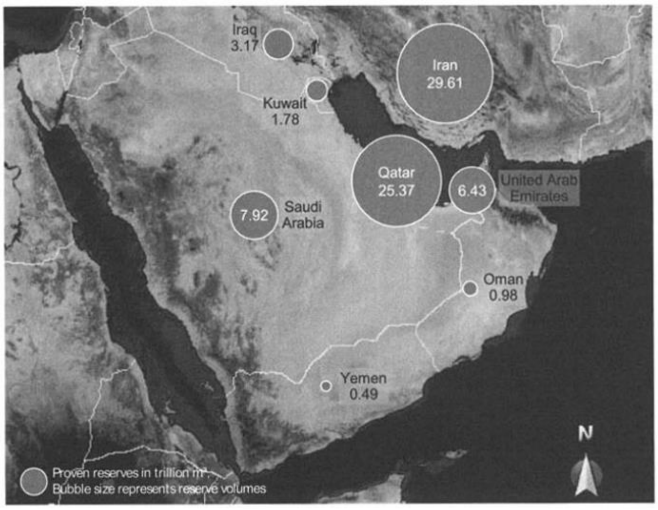
The majority of LNG trade flows are sold under long-term contracts with price linked to a time-average value of crude oil. To supplement contracted supplies, Asian importers also purchase spot LNG cargoes, especially redirected from US. Spot LNG share has increased in Japan since March 2011, from 2% to around 15% today.

The recent unconventional natural gas boom and the consequent gas glut in North America have the potential to fundamentally transform the dynamics of the global natural gas industry. While natural gas prices at Henry Hub have hovered around the US$3.00–3.50/MMBtu level in recent years, prices for contracted LNG imports into Japan have commonly exceeded $14/MMBtu during the same period, spurred by rapidly growing natural gas demand in Asia. Growth in LNG flows from North America to Asia has thus become a real option for the industry (Doshi, 2013).

2.4.5. Middle East's cheap gas

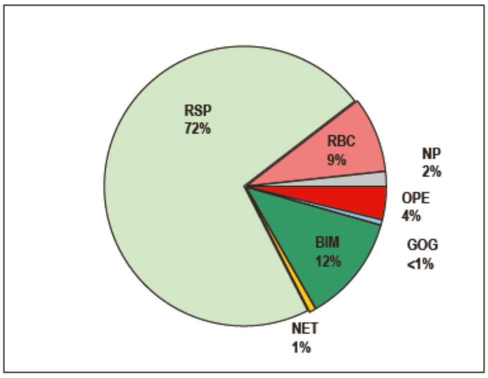
The Middle East is blessed with 40% of the world's proven gas reserves, which makes the region crucial for global energy supplies, especially for the Asian LNG market. Iran and Qatar hold the second and third largest gas reserves in the world after Russia. Saudi Arabia, United Arab Emirates, Iraq, Kuwait, Oman also have significant gas reserves. However, these countries are facing different challenges in terms of accessibility of gas, domestic needs and political environment (Wietfeld, 2011).

Figure 17: Proven natural gas reserves in Middle East



With such large natural gas reserve, Middle East is one of the most important gas exporters worldwide, especially for Asia, since its industrialization. Internally, the gas prices are regulated, either under social or political reasons (Iran, Saudi Arabia, UAE) or below costs, as a form of subsidize for the domestic consumers (Oman, Iraq, Syria). For example, in Saudi Arabia the domestic industrial price is 0.75$/MMBTU. BIM is used for pipeline imports from Turkmenistan to Iran and from Egypt to Jordan, Syria and Lebanon.

Figure 18: Middle East Price Formation 2012



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

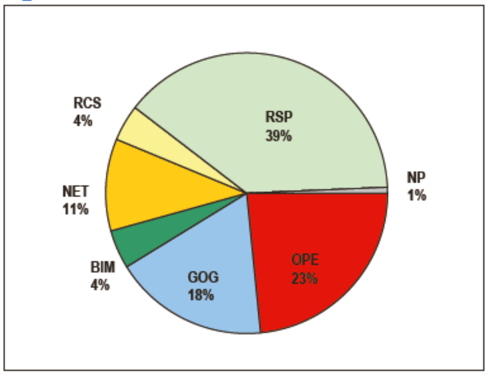
These very low domestic prices are meant also to attract investments in liquefaction plants to sell gas in more expensive markets. In 2011, out of a total of 130 billion cubic meters (bcm) of LNG exported out of the Middle East, Qatar accounted for some 79% or 102.6 bcm, while the smaller producers Oman, Abu Dhabi and Yemen accounted for the rest, each producing roughly between 9 to 11 bcm. Qatar alone accounted for 31% of global LNG exports of 330.8 bcm in 2011. In terms of export destination, Qatar gives priority to supply Europe, US or Asia instead of other countries in Middle East. Therefore, some 48% of Qatar exports headed to the Asia-Pacific, and 42% went to the Europe and Eurasia region. Qatar is the major competitor for market share in UK and Europe against the oil-indexed pipeline gas exports from Russia. In Asia, both Qatar and Australia face the prospects of sharing the Asian LNG market with some volumes of US LNG exports indexed to Henry Hub prices by 2020 (Doshi, 2013).

2.4.6. South American Gas Market

During 20th century, besides the liberalization of the energy industry, countries in South America developed an ambitious political plan for regional integration. Inspired by the European model, it was believed that the integration of energetic sectors could lead to a process of economic integration. Therefore, in South America great efforts were made to integrate different gas markets, starting with substantial investments in transnational pipelines, like Brazil-Bolivia pipeline. Because isolated projects for the pipeline construction to link two markets were made, commerce of natural gas is based on long term contracts with OPE. The main objectives for such contractual agreements are to create a reliable demand for the producing countries and to guarantee security of supply for importing countries. Such contracts have been signed between Brazil and Bolivia, Bolivia and Argentina, Argentina and Chile or Colombia and Venezuela (Almeida & Ferraro, 2013). OPE is also used for most of the domestic production in Brazil and Colombia.

GOG is used for 18% of the gas consumed in South America, mainly for the domestic production in Argentina and LNG imports to Brazil, Argentina, Chile, Puerto Rico and Dominican Republic. However, most of the gas prices in South America are regulated: Venezuela, Argentina, Peru and Bolivia have RSP prices, while Brazil and Colombia use RCS gas prices.

Figure 19: South America Gas Price Formation 2012



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

A particular interesting fact of the South-American geopolitics is the old rivalry between Bolivia, Peru and Chile. In such political context, Peru, which is a potential natural gas exporter for Chile, chose to build a liquefaction plant on the Pacific coast to reach the

European and Asian market instead. Therefore, the development of a gas infrastructure between Peru, Chile and Bolivia was dropped.

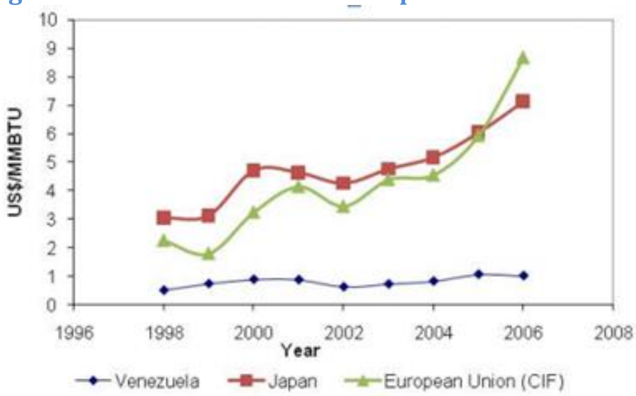
2.4.6.1. Argentina

Initially, the privatization and regulatory governance of the Argentinean gas market in 1992 created a vibrant industry that developed and delivered a high-quality fuel at competitive prices to the advantage of Argentina. Ten years after occurred a major financial crisis which had a significant impact on the energy sector. The price for domestically produced fuel, mainly gas, was regulated and not allowed to increase at the same rate of the inflation. The Government decided to maintain a low price on all primary production factors in order to increase international competitiveness and exports. From this point onwards, gas became increasingly more attractive for consumers, in both the domestic and industrial sector, as the gap between the internationally determined price of oil and the Argentinean determined, very low price of gas increased rapidly. This had the two opposed results that the demand grew rapidly, while the supply remained stable (Ponzo, Dyner, Arango, & Larsen, 2011). The lack of long-term vision combined with short-term policy has together contributed to a deterioration of the industry in recent years, so that Argentina almost tripled natural gas prices to producers as a result of the declining reserves and to encourage conventional and shale drilling. In 2013 the government will pay producers 7.5 $/MMBtu, compared to 2.5 $/MMBtu in 2011 (Gonzalez, 2013).

2.4.6.2. Venezuela, Trinidad and Tobago

Venezuela, together with Trinidad and Tobago, presents the largest natural gas reserves in Central and South America. The prices here are regulated on a social basis. In 1989, when gas prices increased and resulted in a higher transportation costs, thousands of people died after protests. There is, thus, an obvious link between social peace and gasoline (Romero, 2007).

Figure 20: Natural Gas Prices Comparison



Source: (Romero, 2007)

As Figure 20 shows, prices in Venezuela are significantly low in comparison to prices in other markets, such as European or Japanese market. From 1998 to 2006 the gas price in Venezuela raised from 0.5 $/MMBTU to 1$/MMBTU, reaching approximate 1.5$/MMBTU in 2012.

2.4.6.3. Brazil

Brazilian natural gas market is still underdeveloped despite its huge potential and imports. The production is concentrated in the Southeast region, close to the greatest consumption points, Rio de Janeiro and Sao Paulo states, where the infrastructure is more developed. The main production fields are situated in the offshore Basins of Campos and Santos, which contain associated gas. Huge potential is seen in recently discovered pre-salt and shale gas reserves, which could increase with 50% the natural gas reserves of Brazil.

In order to meet the internal demand, Brazil imports gas through pipeline from Bolivia and LNG, from Trinidad and Tobago, Qatar, and Nigeria. Despite the fact that 75% of the imported gas is from Bolivia, due to the political instability of Bolivia, import growth in the future is expected to be met more with LNG than with pipeline imports.

Petrobras is the dominant player in Brazil's entire natural gas supply chain, being responsible for most of the domestic gas production and for gas imports from Bolivia. Besides, it controls the national transmission network and 18 out of the 27 state-owned natural gas distribution companies and controls the gas prices. However, the situation is going to change given that the new Gas Law introduced in 2009 facilitate private investment in the sector and increased competition.

Petrobras' price policy calculates the tariff for gas based on oil prices, meaning that domestic tariffs are high compared with international prices. Although this may be positive for Petrobras, it represents a major hurdle for consumers who must bear higher costs. The average tariff paid by industrial consumers was 16.84 $/MMBtu at the beginning of 2013, 17.3% higher than the average price in a poll of 23 countries—and 231% above the prices charged in the United States. This policy is one of the key reasons behind the stagnation of demand.

The main market for natural gas in Brazil is the industrial sector, which received fiscal incentives to become a gas consumer. In the last decade, the industrial consumption rose with about 180%. Industrial sector has a strategically importance in the natural gas industry, concentrating more than 50% of the consumption. Due to relatively stable demand and the great volume for each consumer facilitate the construction of the infrastructure projects of transportation and distribution. Therefore, the increase in the natural gas consumption reflects the development if the industrial sector itself.

Residential and Commercial sector presents a reduced penetration of natural gas, explained mainly by the climate features in Brazil. A series of difficulties are encountered for the development of natural gas usage in these sectors. Most important ones are lack of a developed distribution network and difficulties to finance the network investments, regulatory instability and high natural prices.

The thermo electric sector experienced strong incentives for natural gas consumption since 2000 given by the privatization of the electric sector that create new opportunities for private investments in generation sector, by the regulatory changes and by the vulnerability of the hydro generation system related to the pluviometric Brazilian regime.

Conclusion

Unlike the oil market, current natural gas markets are not globally integrated. Regional natural gas prices range from $0.75/MMBTU in Saudi Arabia to $4/MMBTU in United States and $16/MMBTU in Asian markets. In European markets, prices fall between North American and Asian prices, reflecting a mix of spot prices and contract prices with oil price indexation. Spot prices at UK National Balancing Point averaged $9.21/MMBTU in November 2011.

One of the reasons for such a price divergence is the different pricing mechanism used in each regional market. Traditionally, world gas markets have operated as three largely self-contained regions: North American Market, Europe – supplied by Russia and Africa, and Asian Market –linked to Middle East. In general, U.S. has gas-on-gas competition, open access to pipeline transportation and manages risk through spot and derivatives markets. The European market relies more heavily on long-term contracts linked to oil price, and its pipeline access is restricted. The main supplier of Europe is Russia, which uses to export gas at very high prices in order to subsidize the domestic consumption. Asia uses long term contracts benchmark priced to crude oil; this structure has kept LNG prices in Europe and Asia high relative to other regions. Its main LNG importer is Middle East, which has 40% of the worlds gas reserves and very low, regulated domestic prices. These market features, along with the availability of domestic natural gas resources and geopolitical interests, established the boundary conditions for the development of global natural gas markets (MIT, 2011).

The regionalized and diversified structure of natural gas markets stands in contrast to the oil global market as a consequence of the difference in physical characteristics between these commodities: oil has a very high density at normal conditions of temperature and pressure, which makes it easy to be transported at a moderate costs; on the contrary, natural gas transportation costs constitute a significant fraction of its total delivered cost. Moreover, unlike oil, gas can be substituted in all its markets: power generation, industrial process, building heat.

Third Chapter: Drivers and constraints for achieving a global gas market and price

"Better out than in: If Barack Obama wants a cleaner world and a richer America, he should allow natural-gas exports" (The Economist, 2013)

Introduction

As it has been described in the previous chapter, natural gas prices are characterized by regional markets, by the location of natural gas reserves that lead to an advantage for some countries, advantage seen in the difference between domestic and export prices. Currently world gas trade is concentrated in three regional markets: North America; Europe –served by Russia and Africa; and Asia – with a link to the Middle East. There are significant movements of gas within each market but limited trade among them. Due to the different pricing structure between these regions, prices can differ substantially among regions.

However, until 2008, the prices of these three regional markets were, to some extent, convergent. The difference between the Asian LNG price, the European UK NBP and German Border Price of gas imports from Russia and the North American Henry Hub was not greater than $2/MMBtu . The boom in shale gas production in the United States since the mid-2000s has boosted gas supplies substantially, removing the anticipated need to import LNG and driving down prices (MIT, 2011). More recently, the shutdown of nuclear facilities after the March 2011 Fukushima disaster has increased demand for LNG, pushing prices up to ~$15-18/MMBtu in Japan. As a result, the regional gas markets start moving in a different rhythm from each other and this disconnection is reflected in large price differentials between them: in June 2012, spot gas was trading at as little as $2.10/MMBtu at Henry Hub, compared with $9.90/MMBtu in the United Kingdom, $12/MMBtu for spot LNG in the Mediterranean and $17.40/MMBtu for spot LNG in northeast Asia.

Unavoidable, this price divergence has led to industrial competitive advantage for markets with lower gas price. Therefore, gas based industries start to migrate towards these markets to such an extent that rose the question of a possible reindustrialization of the North American market. In this context, the gas price evolution is of a great importance.

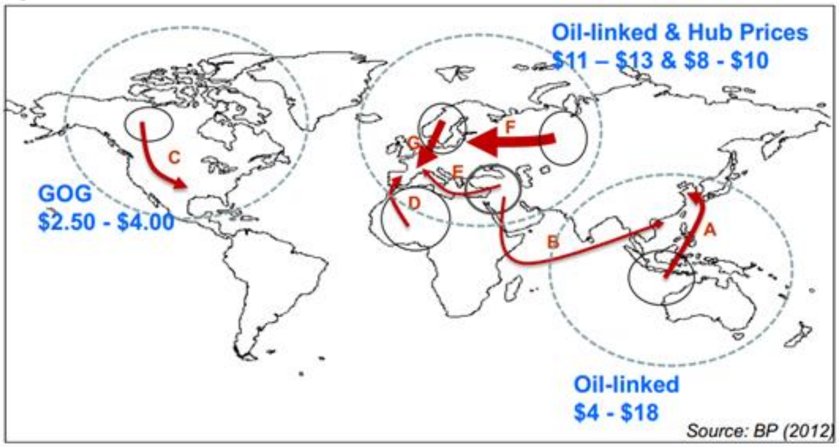
Whether or not the prices are to converge again and how they will evolve in the short or long term, no one can tell exactly. However, despite the arbitrage opportunities that are driving towards a global gas price, there are significant constrains in this sense given the particularity of gas as a commodity. Therefore, in the short and middle term a gas price convergence is difficult to be foreseen under the present conditions. This chapter builds a typology of the main drivers and constrains towards the formation of a global gas market and a global gas price, bringing evidence to the hypothesis that prices will be decoupled in the next period of time. Price evolution is driven by internal factors: price formation and market structure of each market, evolution of supply and demand, and also by external factors as LNG trade that might facilitate arbitrage between markets and achieving a more uniform price by applying the law of one price. However, currently LNG capacity substantially limits the traded volumes, leaving thus space to price differences between markets higher than the transportation and transaction costs.

3.1. Different market structure and price mechanisms

Gas markets are fragmented by legal and regulatory requirements, distance and different approaches to contracting. For achieving a global gas market and gas price, a homogenization in the market structures and price mechanisms would clearly help.

Unlike the global oil market, which reflects the global demand and supply, the international market for gas lacks international transparency and benchmarks. There is yet no international reference for gas price, each market pricing gas following different rules. In US and UK gas is priced based on regional supply and demand balance in the gas trading hubs (GOG mechanism): Henry Hub in US and National Balancing Point in UK. However, in continental Europe and Australasia prices are characterized by the dominance of long-term contracts between gas producers and consumers, and a price mechanism linked to oil prices (OPE mechanism). These gas contract prices lack not only global transparency, but often regional transparency due to prices being commercially negotiated on confidential contractual terms (more detailed in Chapter 2: Gas Pricing in International Market).

Figure 21: Global Gas Trade Flows and Gas Price Formation Mechanism 2011



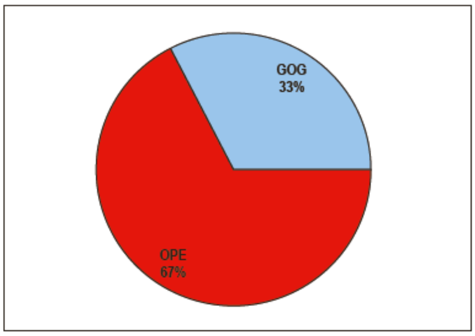
Source: (BP, 2012)

This sub-section analyses the probabilities of a significant migration in Asian and European market from OPE to GOG pricing mechanism. The first striking difference between the GOG markets (US and UK) and OPE markets is that a large majority of Asian and European countries depend on gas imports to meet demand. These markets are highly concentrated in the number of suppliers, whereby purchases must hedge investment risks and enforce a higher level of longer-term planning for security of supply, done usually through long term contracts (Reynolds & Richardson, 2012).

There are seven mechanisms used to price gas around the world. A transition towards a single mechanism is impossible to achieve in the near term and not quite probable even in long term. However, the same pricing mechanism for the traded gas is the first step to be done.

The gas consumption from domestic production is usually priced differently than the exported gas. In many markets the domestic gas is regulated by the government, while the exported gas is only priced under OPE and GOG. As the domestically consumed gas priced mechanisms is more difficult and much less probably to be changed and affects less the formation of a global gas market, we will focus on the imported gas pricing. 33% of the imported gas is priced on GOG competition and it accounts for all imports and exports towards and from UK, US, Canada and Mexico. Oil Price Escalation is applied for all other imports, most of them being towards European and Asian market (mainly Japan, Korea, China and India).

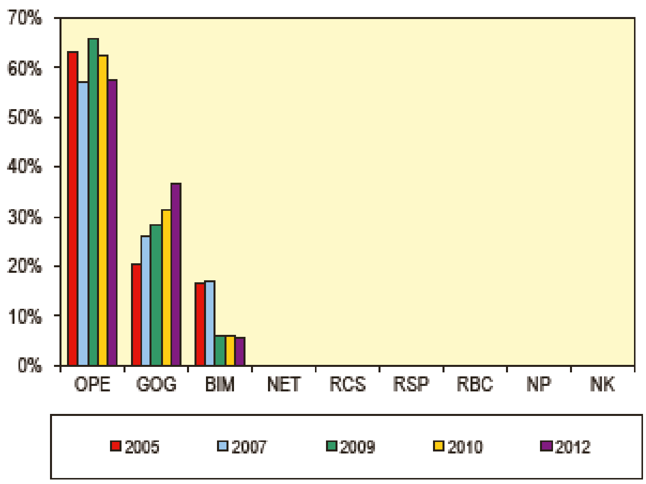
Figure 22: World Price Mechanism 2010- Total Imports



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

A transition from OPE towards GOG is clear in the last years. From 2005 to 2007, 6% of the traded gas switched from OPE pricing to GOG pricing and then in 2009 BIM fell from 17% to 6%, increasing share to OPE and GOG. Since then, OPE has lost share by around 9% and GOG gained similar share. One of the reasons for the transition from OPE to GOG formation mechanism is that lately the GOG prices are much lower than OPE prices, due to the decoupled between the oil prices and Henry Hub Prices since shale gas boom. Therefore, mostly Europe is trying to switch as fast and as much as possible towards a GOG price formation for the imported gas.

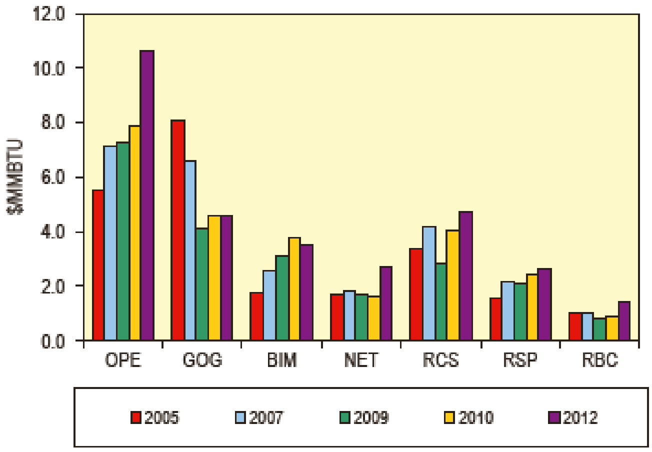
Figure 23: World Price Formation mechanism 2005- 2012 - Total Imports



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

As Figure 23 illustrates, the volumes of gas traded under gas on gas competition is annually increasing, not only at the expenses of OPE but even more at the expenses of gas volumes priced under bilateral monopoly. This is a sign of more arbitrage between markets.

Figure 24: Wholesale Price Levels 2005 to 2012 by Price Formation Mechanism

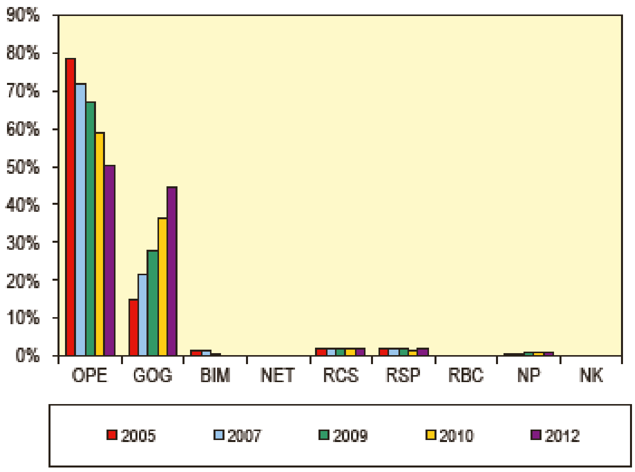


Source: IGU Report 2012 Wholesale Gas Formation Mechanism

3.1.1. Price formation mechanism trends in Europe

Europe is one of the regions where the most significant changes in price formation mechanisms have taken place, especially a continuous transition from OPE (from 78% in 2005 to 50% in 2012) to GOG (from 15% in 2005 to 45% in 2012). These changes are mainly reflected in the decline in the volume of gas imported under the traditional oil price escalation and increase in the imports of spot gas and increasing volumes traded at hubs. The ending of contracts or the renegotiation of the terms to include a proportion of hub/spot price indexation in the pricing terms and in some cases a reduction in the take or pay levels are the main means used to decrease the OPE utilization (IGU, 2013).

Figure 25: Europe Price Formation 2005 to 2012

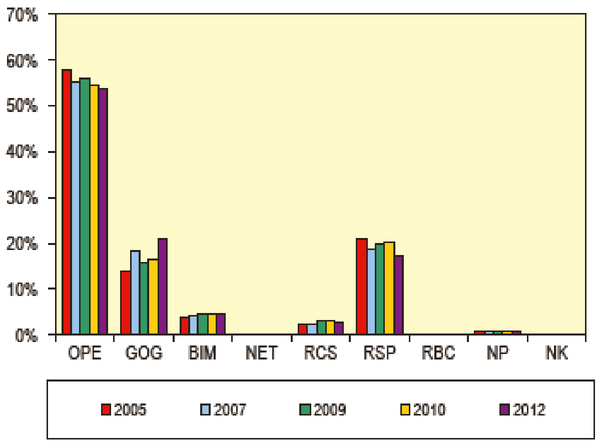


Source: IGU Report 2012 Wholesale Gas Formation Mechanism

3.1.2. Price formation mechanism trends in Japan and Korea

In Asia Pacific changes has not been consistent over time, but the rise in GOG has been achieved due to the ascendant trend of spot LNG imports, mostly in Japan and Korea. However, the pricing in this area is likely to remain predominantly oil indexed this decade. Most price re-opens of LNG contracts could be in 5 or 10 years, and meanwhile a more extensively move to hub based pricing is unlikely. Indeed, Japanese importers will try to approach a supply and pricing diversification trend, but weather this will lower the prices, is debatable. In 2012, Asian buyers started to consider shifting from the traditional oil linked LNG long term contract with fixed destination. Japanese utilities intensified their interests in US LNG, but to accelerate the breakthrough in the oil-linked system, the Asian buyers would need to find more traditional sellers willing to sell them LNG at non oil-indexed pricing (IGU, 2013). Major LNG buyers in Japan and Korea expressed targets of around 20% of forwards LNG imports to be priced under gas-on-gas competition. Importing 20% of their gas demand from US will not be enough to fundamentally change the prevailing Asian Basin oil linked pricing dynamic (J.P.Morgan, 2013). In addition, there is no guarantee that all US exports will be sold on a hub basis and the foreseen great Australian exports will be sold under oil price escalation.

Figure 26: Asia Pacific Price Formation 2005 to 2012



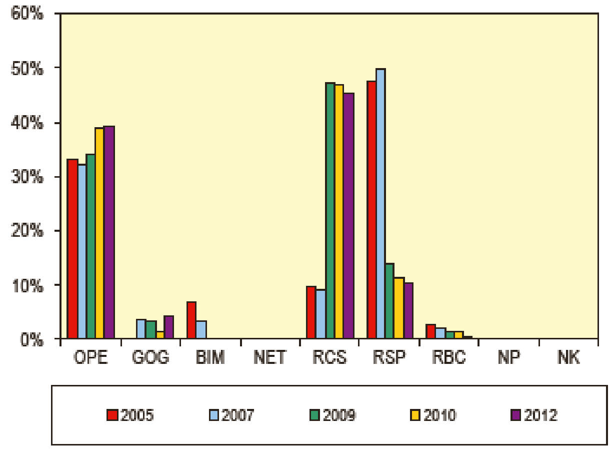
Source: IGU Report 2012 Wholesale Gas Formation Mechanism

Moreover, gas buyers in Japan and Korea value more security of supply over price and, until deregulation occurs in their gas markets, they will continue to purchase relatively high priced LNG. Therefore, the way towards liberalized gas markets appear to be quite long for Japan and Korea.

3.1.3. Price formation mechanism trends in India and China

In China and India the OPE price escalation is the most used in traded gas: the move from BIM to OPE reflected the change in the pricing mechanism of the Qatar LNG contract to India between 2007 and 2008, and the recent rise in OPE was due to the start of pipeline imports from Turkmenistan to China. GOG is exclusively used in spot LNG imports. The changes in RSP and RCS were due to the change in price formation of the domestic gas in China.

Figure 27: Asia Price Formation 2005 to 2012 -India and China



Source: IGU Report 2012 Wholesale Gas Formation Mechanism

3.2. Evolution of Henry Hub Price

The main reason that leads to the current price differences in the gas regional markets is the emergence of the unconventional gas in US, lowering the Henry Hub price. Henry Hub price at the moment (August 2013) is USD $3.43/ MMBtu[1], almost one quarter of the price in July 2008 (US $ 12.69/MMBtu). There are speculations that the current price is not sustainable, and it doesn't cover the actual cost of fracking and therefore, it will quickly increase again. The future economics of shale gas is difficult to predict due to the high uncertainties in the price drivers. Firstly, shale gas production is very much in its infancy. Most of the plays present very different geological and operational challenges, but it is reasonable to expect that as operators gain experience, progress on addressing these challenges will be made and there may be the opportunity to improve the relative economics of the plays. Another huge uncertainty is related to the policies that will be taken regarding the environmental externalities the drilling is suspected to produce.

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[1] Source: EIA Website

This section identifies the main internal drivers of the natural gas price in US and shortly analyzes each of them. Along with internal supply and demand, natural gas price could be driven also by some regulation interference related to the environmental impact that fracking has, by the potential LNG exports that are planned to start with 2016, and by the natural gas liquids market.

3.2.1. Supply

The most striking feature of the gas production in the US in the past decade has been the emergence of shale gas, which has had a great impact upon the prices. Thus, one of the main drivers of gas price in US is represented by the amount of shale gas reserves and by its exploitation rate and costs. Data and analysis show that a price between 4 and 6$/MMBtu is sustainable for a sufficient large amount of shale gas production, gas prices being thus driven downwards as huge shale gas reserves exists at competitive costs.

Natural gas resources

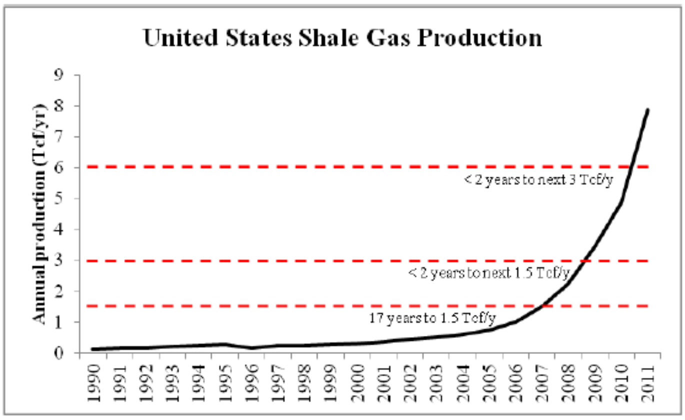
US Energy Information Administration (EIA) conducted a review of shale gas resources, listing all known shale gas plays as of January 2009, as follows:

Shale Play	Shale Gas Reserves (trillion cubic feet)
Marcellus	410
Barnett	75
Utica	43
Fayetteville	38
Barnett- Woodford	32
Devonian	32
Woodford	29
Eagle Ford	22
Mancos	21
Antrim	20
Lewis	12
New Albany	11
Bakken	10
Williston- Shallow Niobraran	7
Cana Woodford	6
Floyd-Neal &Conesuaga	4
Hilliard-Baxter-Mancos	4
Cincinnati Arch	1
Total	**798**

Table 1: List of Shale Gas Plays in US

Although shale resources have been produced in US since 1821, the volumes have not been significant as it was considered uneconomical. The situation changed fundamentally in the lasts years with the technological advances that enabled shale gas exploitation at economical feasible rates.

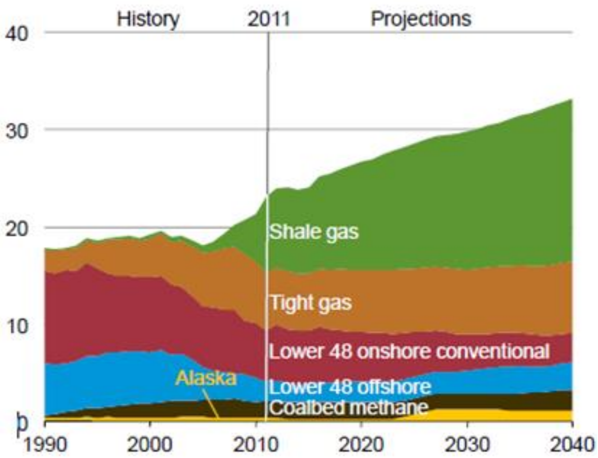
Figure 28: US Shale Gas Production Evolution



Source: (Cohen, 2013) based on EIA Data

The EIA Projections shows that natural gas production will increase in US from 2011 to 2040 by 44%, due to development of shale gas and tight gas resources.

Figure 29: Natural gas production by source in US (trillion cubic feet)

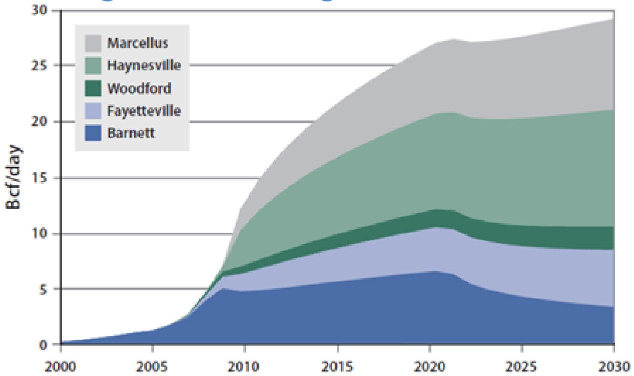


Source: (EIA, 2013)

Shale gas production, which already accounts for a tenth of total U.S. energy supply, is expected to be the primary driver. EIA anticipates a growth of 113% in shale production from 2011 to 2040, bringing the greatest contribution to natural gas production growth. However, it is important to note that there is considerable variability in the quality of the resources, both within and between shale plays (MIT, 2011).

Increased gas production and large shale gas reserves puts US in the position to consider becoming a self sufficient natural gas exporter in few years. Merely four years ago, US was constructing LNG imports terminals, whereas today, it is applying for permits to retrofitting the very same terminals in liquefaction facilities. The figure below indicates how production from the top five shale plays might grow, if drilling were to continue at 2010 levels for the next 20 years. The production potential of the shale resource is very significant. However, the current rapid growth in production can continue only for some time as the quality of drilling prospects declines as the plays mature.

Figure 30: Potential Production Rate that could be delivered by the Major U.S. Shale Plays up to 2030, given 2010 drilling rates and resource estimates



Source: (MIT, 2011)

Breakeven price of shale gas

It is arguable that the costs of drilling are not covered by the prices. Varies studies have been preceded on the break even well price of shale gas. The cost of exploiting shale gas is formed by few different costs:

- Finding and development cost is the cost to purchase and develop a property and acquire and evaluate seismic data;
- Lease operating expenses are the well's costs associated with extracting the gas and liquid products;
- Transportation and fractionation costs are largely determined by each play's distance to hubs;
- Royalties constitute the share of revenues that are returned to the original owner of the land used for oil and gas extraction; in US the owners of the land have the rights upon the whole underground area, unlike in Europe where the government owns the underground. Royalties are quoted as an interest rate, a percentage of ownership of future production from a given leasehold, generally ranged from 13 to 27%;
- Pre-construction costs include leasehold, permitting and site prepping fees. These are one-time upfront payment to the landholder, according to the surface of land leased. Permitting fees, assumed to be $2.500 for all plays, include costs of

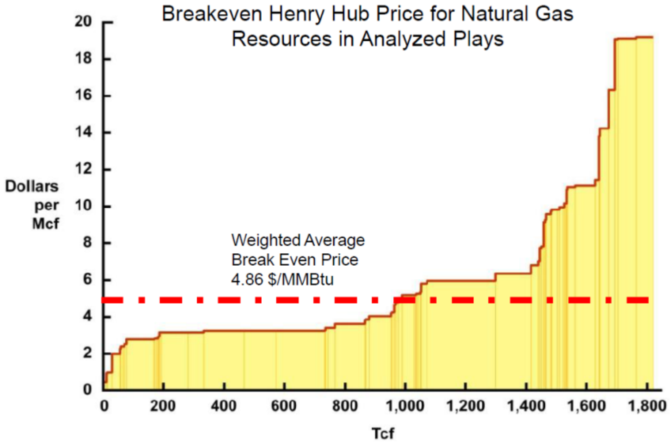
building a road for transportation, a pond for hydraulic fracturing water, laying rock for the construction of the drilling pad;

- Tangible costs of drilling represent costs related to well drilling that do offer salvage value. These expenses were depreciated over 10-year period and are assumed to be 25% of total drilling and completion costs;
- Intangible costs of drilling include costs of labor, chemicals, drilling fluid and any items associated with drilling activities that offer no salvage value. They are assumed to be 75% of the total drilling and completion costs.

A study preceded at Harvard University takes into account 11 of the shale gas plays, representing 90% of the total shale gas reserves in US, and based on all the costs enumerated above and an IRR of 10%, it concludes that the weighted average price calculates the 10-year typical breakeven gas price to be $4.04/MMBtu. This price represents the wellhead price, which it to be added on top the transportation costs to the end user, on average of $1/MMBtu.

An MIT Report analyzes the breakeven gas price as a function of initial productivity for the five major US shale plays and concludes that for Marcellus play, the breakeven price is 4$/MMBtu, for Barnett is 5.48$/MMBtu, Fayetteville has a breakeven price of 5.25$/MMBtu, Haynesville 5.04$/MMBtu and Woodford 5.96$/MMBtu (MIT, 2011).

Figure 31: Breakeven HH Price



Source: (IHS, August 2013)

Another recent study made by IHS finds a weight average breakeven price of 4.86$/MMBtu for plays that together account for 1000 Tcf, a sufficient amount for many years, while Deloitte's Centre for Energy Solutions estimates that 1200 Tcf of gas in the US would be economically available for production at 6$/MMBtu. An analysis from Brookings Institute assumes a price of 5 $/MMBtu and Michelle Foss from Oxford Institute calculates an average breakeven cost of 6$/MMBtu. The supply curve produced in the Rice University study shows that the vast majority of gas is economically producible at 6 $/MMBtu. In its most recent Annual Energy Outlook the EIA provided an long term estimate for US gas prices ranging from 3.3 $/MMBtu in 2012 to 7.37 $/MMBtu in 2035.

Study	Breakeven cost for US shale gas (US$/MMBTU)
MIT Study[2]	4 -6
Oxford Institute[3]	6
Harvard University[4]	4.04
Deloitte Study[5]	6
IHS Study	4.86
Brookings Institute	5
Rice University, Texas	4-6
EIA Annual Energy Outlook[6]	3.3– 7.37

Table 2: Studies of Breakeven Cost for US Shale Gas

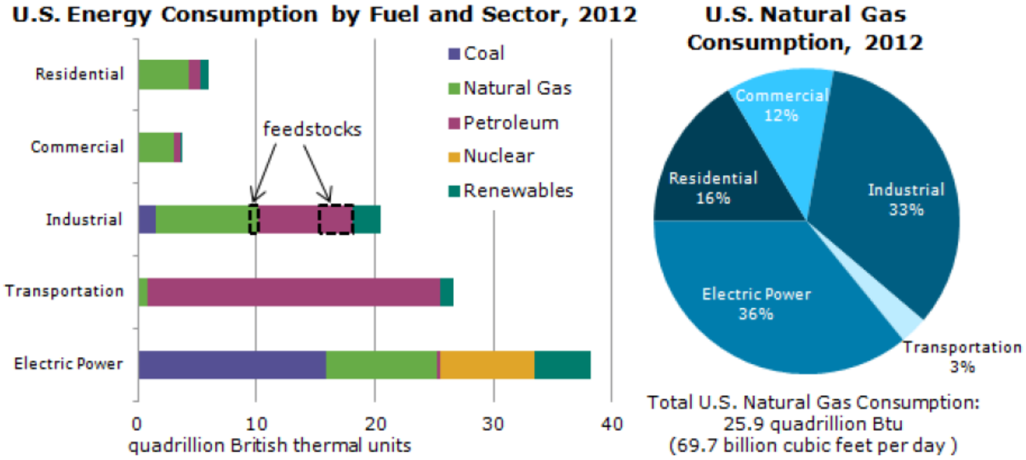
It is therefore reasonable to assume that a price between 4 and 6 $/MMBTU is sustainable for a sufficient large amount of shale gas production. Therefore, from the supply point of view, gas prices are driven downwards as huge shale gas reserves exists at competitive costs.

3.2.2. Demand

Natural gas is the second-largest primary source of energy consumed in the United States, its consumption being tied to economic activity. It is heavily consumed in industrial sector, along with petroleum, and in electric sector, along with coal and nuclear. Residential and commercial sector use predominantly gas as energy source.

[2](MIT, 2011)
[3](Foss, 2012)
[4](Cohen, 2013)
[5](Deloitte, 2012)
[6](EIA, 2013)

Figure 32: Natural Gas Consumption in 2012



Source: (Bipartisal Policy Center, 2013) based on EIA Data

The new reality of extremely abundant and reasonably priced natural gas has already led to significant national benefits in the last 5 years in plenty of areas:

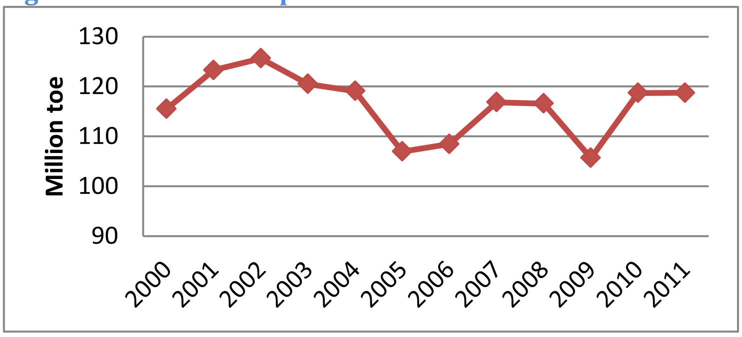
- lower carbon emissions in the power generation sector;
- lower utility bills for consumers;
- the creation of hundreds of thousands of new, high-paying jobs;
- tens of billions of additional tax collections at the state, local and federal levels;
- billions of dollars in royalty payments to hundreds of thousands of mineral owners;
- massive new investments and new job creation by industries that use natural gas as a feedstock, such as plastics, fertilizer and chemicals;
- hundreds of billions in economic impact across the breadth and depth of the nation (Blackmon, 2013);

Many of these benefits involve a higher demand of natural gas, while new application of gas in a variety of sectors and uses continue to be improved. This subsection deals with the evolution of the internal gas demand, external demand (LNG) to be treated in a separate section. Increased natural gas consumption in the future will be primarily driven by overall economic growth and increased demand in the electric power and industrial sectors. If large parts of the U.S. economy are to shift to natural gas, sufficiently low long-term prices that maintain the advantage of gas over other fuels are likely to be required. However, the increases in demand associated with the shifts in favor of gas use could result in prices also increasing, perhaps bringing into question the economic advantages available to potential users of natural gas. On the other hand, if wellhead prices are to remain too low in the long-term, the exploration and development activities might not make sufficient profits and might slow production. However, the increase in demand will not hurt very much the prices as sufficient supply exist and US' economy needs a strong recover from the financial crisis.

Industrial sector

Even if considerable increase in demand in industrial sector wasn't seen in the lasts years, studies predict significant increase in the next years, due to the gas-based industries that are heavily investing in US in the moment (as it will be discussed in the next chapter).

Figure 33: Gas Consumption in Industrial Sector

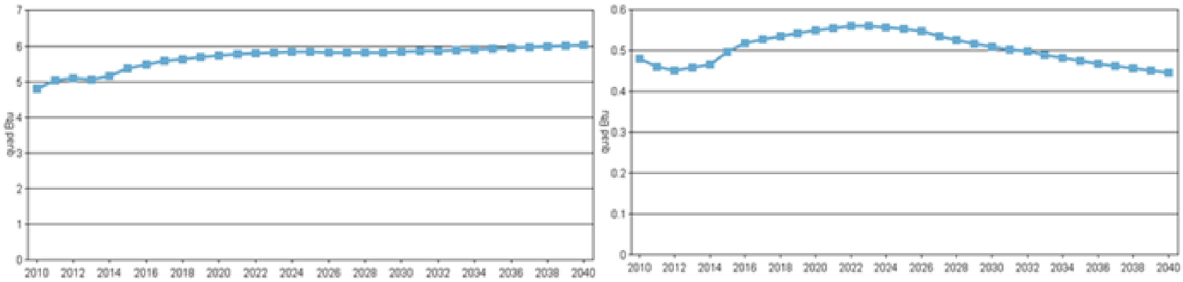


Data Source: IEA Energy Balance for OECD Countries

The Annual Energy Outlook released this year (2013) by the US Energy Information Administration forecasts the evolution of industrial natural gas consumption. Reference case projection is a business-as-usual trend estimate, given known technology and demographic trends. It is assumed that current laws and regulations are maintained throughout the projections.

EIA forecasts that natural gas in industrial sector increases by an average of 0.5% per year from 2011 to 2040, a big contribution being brought by the energy intensive industries that take advantages of relatively low natural gas prices, particularly through 2025. After 2025, growth in the sector slows in response to rising prices and increased international competition. Natural gas used in heat and power in Industrial sector will gradually increase with 20%, which is considerable if we take into account the efficiency progress in the technology. EIA forecasts a higher growth in natural gas used as feedstock in the industry, but starting only with 2014-2015.

Figure 34: Natural gas used as heat and power in Industrial sector (right) and natural gas used as feedstock in Industrial sector (left)

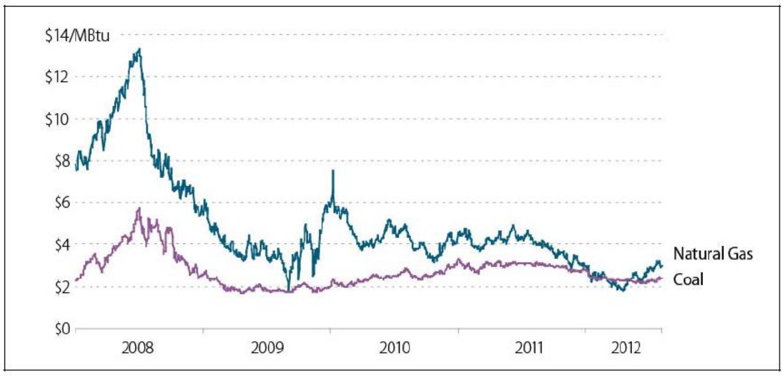


Source: (EIA, 2013)

Electric power sector

Fuel costs account for 40% of the total production costs of electric power generation. Therefore, the electric power sector was the first to react to the low gas prices. The price of natural gas has a significant effect on competing generation options, particularly coal and renewable generators. Also important are the relatively lower carbon emissions of gas-fired plants relative to coal fired power plants and the relatively high capital investment costs of coal-fired plants compared to natural gas-fired plants. On top of that, if EPA (Environmental Protection Agency) will restrict the emissions from coal-fired units so that in order to meet the new benchmark it will be needed the process called "carbon capture and storage" (CCS), the coal-fired generation costs will increase considerable. CCS is a process in which carbon is separated from emissions, yet not economically viable. Therefore, gas generation will become substantially cheaper than coal generation, increasing thus the gas share in the power matrix.

Figure 35: Natural gas vs coal prices

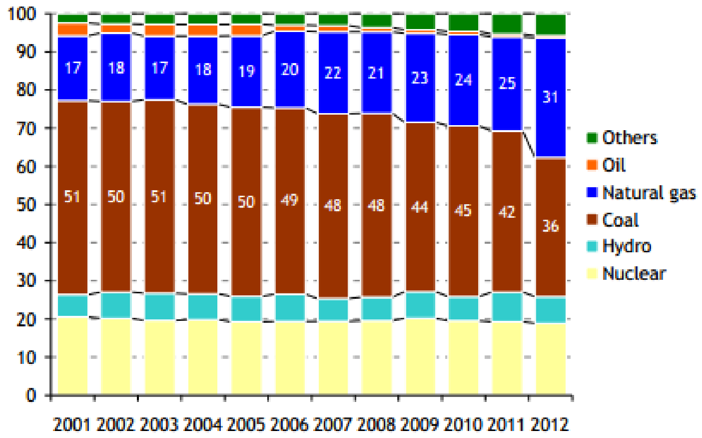


Source: Bloomberg New Energy Finance.

An additional benefit of the gas fired plants is their flexibility, the capability of increasing and decreasing output efficiently and cheaply. All these advantages together with low natural gas prices have accelerated a shift away from coal and towards natural gas in the power sector over the last five years. Natural gas fired generation grew by 9% while coal generation declined 10% between 2007 and 2012, and it is expected that natural gas fired generation will account for about 60% of the generating capacity in US until 2035.

Nevertheless, coal will continue to retain an important share in the power matrix in US as many large producers are located near coal mines, insuring low transportation costs. In some regions, switching from coal to gas involve the construction of new natural gas pipelines, which might not be economically worthy if increased demand in electricity or other sector will rise natural gas prices.

Figure 36: Power Generation Mix in US



Source: EIA, "Electric Power Monthly"

Transportation sector

Natural gas does not play a big role in US transportation sector, oil based products, gasoline and diesel fuel being the major fuel used. However, the low gas prices are incentivizing planning for incorporating more natural gas into the transportation fuel mix. As the price spreads between diesel fuel and natural gas, natural gas gains competitiveness. Diesel fuel cost is largely depended of crude oil cost, historically a barrel of oil being six times the cost of a unit of natural gas. Since shale gas boom, a barrel of oil might cost over 30 times the cost of a unit of natural gas. Even in EIA's most aggressive case for heavy duty vehicles running on natural gas, in 2035 natural gas comprises less than 9% of the highway vehicle fuel mix (Pirog& Ratner, 2012).

Natural gas can become a greater part of the transportation fuel mix in a variety of ways: compressed natural gas (CNG), LNG, methanol, gas-to-liquids, fuel cells and electricity, but the near term opportunities are LNG and CNG for long-distance trucking. However, the introduction of more natural gas in transportation sector will require changes both in vehicles and in infrastructure and investments have to be made both by consumers and industry. Shell announced a plan to add LNG pump at 100 locations for truck refueling, to enable LNG trucks to travel across the entire country.

Residential and Commercial Sector

Residential and commercial use of natural gas is not projected to increase as significantly as other sectors of the economy, as the cost of gas doesn't represent a large share in the total costs of the sectors.

3.2.3. Natural Gas Liquids (NGLs) Market

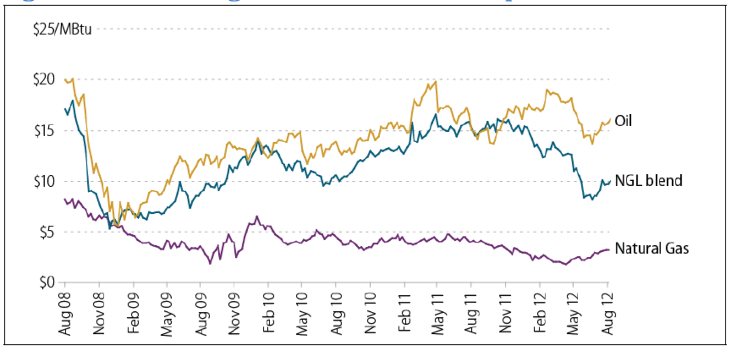
Another major driver of shale economics is the amount of hydrocarbon liquid produced along with gas. Natural gas liquids are historically indexed to oil. Therefore, the amounts of liquids founded with gas can have a considerable effect on the breakeven economics — particularly if the price of oil is high compared to the price of gas (MIT, 2011). Therefore, it becomes economically profitable for the producer to sell gas cheap if, besides the revenue from gas, he receives revenue from selling gas by-products that are oil indexed.

The fact that gas prices have been driven to low levels since 2009, while oil prices, determined by global market forces, have remained high, has led producers to seek liquid rich gas plays, such as certain areas of the Marcellus or the Eagle Ford play in Texas. These plays enable more gas production, even at low gas prices, thus putting further downward pressure on gas prices (MIT, 2011). However, because lately liquids-rich shale gas production has increased, the NGL market is experiencing oversupply and lower prices.

A recent diverge of ethane prices from oil, and similar trends have been observed in the case of propane and other NGLs (Cohen, 2013). It is possible that NGL prices diverge even more in the future, resembling eventually current natural gas prices. This would result in lower revenues from NGLs and thus higher the shale breakeven price.

In conclusion, NGL markets have pushed down so far the gas prices as they were bringing considerable extra revenue to the gas producers due to the traditionally oil price indexation. However, if LNG prices will continue decreasing, natural gas prices will be forced to increase. The future market for liquid heavily dictates shale profitability.

Figure 37: Natural gas, Oil and NGL Brent prices



Source: Bloomberg New Energy Finance

Ethane and propane production have raised the last couple of years their prices have been driven more by their own market fundamentals of supply and demand.

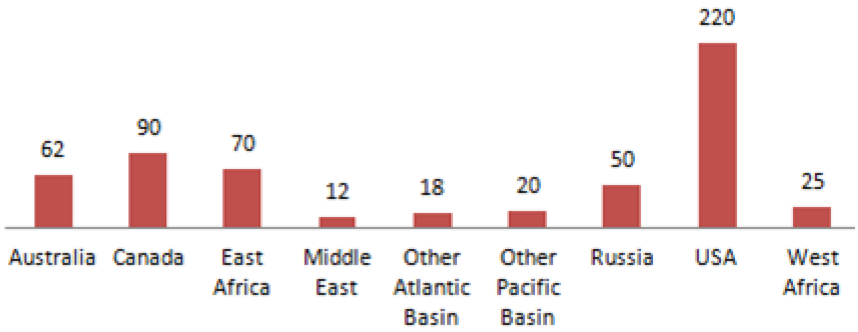
3.2.4. LNG exports

In EIA projections, 93% of the natural gas produced in the United States remains available to meet domestic demand. It is assumed that gas prices increase from their current levels to reach $5.5/MMBtu in 2020, largely driven by the domestic dynamics of supply and demand. In short, this is not going to be an increase in exports at the expense of rising costs at home. LNG exports will act as a primary outlet for excess shale gas extraction. Moreover, a huge market as US is not going to be strongly contaminated by the arbitrage with other markets.

The US LNG exports motivation

Development of shale gas extraction has turned US' natural gas market upside down. Only five years ago, US was prepared to import LNG to fill the gap between the rising demand and the stagnant domestic supply of natural gas. Now, in the new market conditions, US is foreseen to become gas self-sufficient by 2020 and, due to the gas price difference between the local market and Europe and Asia, US interest in exporting LNG has arisen. In November 2012 Henry Hub prices were of 3.54$/MMBtu, while Japanese average import price was over four times higher (15.31$/MMBtu) and the NBP in UK was over three times higher (10.74$/MMBtu).

Figure 38: Proposed Liquefaction Capacity June 2013 (mtpa)



Data Source: IGU, World LNG Report, 2013

In these market conditions, interest in exporting gas has, unsurprisingly, grown and a number of gas liquefaction projects are planned (Figure 38). Just how much LNG export capacity is built and how much gas is eventually exported hinges on whether regulatory approvals for new export terminals are granted in the United States and whether these regional price differentials are maintained.

LNG Export Projects

Projects for constructing new LNG exports terminal for converting existing LNG import terminals into exporting ones require DOE (Department of Energy) approval to export LNG to FTA countries, which is automatic, and non – FTA countries, which is more controversial, and FERC approval for the construction and operation of the plants. From the FTA countries, only South Korea presents important LNG import demand, therefore the approval to export LNG to non-FTA countries is crucial for prospective US exports. Currently, out of the 245 million tons of announced LNG capacity, only 16 million tones have received fully permission, or from the 16 different projects, only one –the Cheniere's Sabine Pass project in the Gulf of Mexico- has obtained both non-FTA approval from DOE and facility approval from FERC.

Company	**Non- FTA Capacity (Bcf/d)**	**Non-FTA DOE Status**
Sabine Pass Liquefaction LLC	2.2	Approved
Freeport LNG Expansion and FLNG Liquefaction, LLC	2.8	Under Review
Lake Charles Exports, LLC	2.0	Under Review
Carib Energy (USA) LLC	0.01	Under Review
Dominion Cove Point, LLC	1.0	Under Review
Jordan Cove Energy Project, LP	0.8	Under Review
Cameron LNG, LLC	1.7	Under Review
Gulf Coast LNG Export, LLC	2.8	Under Review
Gulf LNG Liquefaction Company, LLC	1.5	Under Review
LNG Development Company, LLC	1.25	Under Review
Southern LNG Company	0.5	Under Review
Excelerate Liquefaction Solution I, LLC	1.38	Under Review
Golden Pass Products LLC	2.6	Under Review
Cheniere Marketing LLC	2.1	Under Review
CE FLNG, LLC	1.07	Under Review
Pangea LNG (North America) Holdings, LLC	1.09	Under Review
Total	**24.8**	

Table 3[7] : Applications received by the DOE to export domestically produced LNG to non-FTA countries as of January, 2013

[7] Source: DOE Data

Exports Support and Opposition

The shale gas LNG exports are a controversial topic nowadays. Supporting voices sustain that such exports will increase the GDP of the country, will create jobs across the LNG supply chain and current account deficits would reverse. Moreover, the US would gain geostrategic opportunities to reposition itself in the Asia-Pacific.

However, sufficient lobby is made in the US government to keep most of the shale gas for domestic demand. The primary rationale behind LNG export opposition is to keep domestic natural gas prices low, assuring the competitive advantage to the US industry and enable emission decrease by replacing coal with natural gas in power generation. In addition, exports will require more fracking, which is strongly disapproved by environmentalists (Cohen, 2013). Nevertheless, it is forecasted that no more than 10% of the production will be exported. Therefore, in principle, the small amount of exports won't be able to influence such a well-developed and great internal market as US and its price.

3.2.5. Environmental regulation

The environmental impact of shale gas fracking is a very controversial topic at the moment. Whereas Europe claims fracking is too damaging, the coal usage in energy mix increased considerable due to the cheap coal imports from SUA, and increasing thus the CO_2 emissions. It is suspected that shale gas exploration produces serious local damages, but the increase of gas utilization in the power generation at the expense of coal is significantly reducing the CO_2 emissions.

A tighter regulatory environment for natural gas exploration and production, if it rises costs significantly, would likely result in slower supply growth and could reduce some of the benefits brought by shale gas to the US economy. If low prices and abundant supply increases demand, and then regulation slows supply growth, a price spike is likely to result. However, in the past several years, a number of states have adopted stricter production regulation, and yet production has continued to grow (Colorado, North Dakota, Ohio, Pennsylvania and Wyoming) (Pirog& Ratner, 2012).

Technological improvements, along with new environmental policies, will help reduce the negative impact of hydraulic fracking, but in my opinion US will not permit any regulation to lead to a reduction in shale gas supply, given the economic and environmental benefits the gas availability is bringing to the country. Therefore, gas price is unlikely to be strongly affected by environmental regulation.

Environmental impact of fracking

Shale gas production involves drilling a well bore into the reservoir rock formation and then forcing water, sand and chemicals into the well at high pressure to create fractures or fissures in the rock. Once the fracture is open, the released gas flows out of the fractures and into the well bore. This has led to some serious concerns raised by the environmentalist such as groundwater contamination, alarming high water usage, surface water and soil risk. There have been serious agitations and environmental campaigns against the use of hydraulic fracturing or "fracking" process.

In addition, the shale gas production process vents significantly higher amounts of methane (CH4) into the atmosphere than conventional gas, which effectively undercuts the benefits of shale gas in reducing greenhouse gas emissions. In this sense, the Environmental Protection Agency (EPA) has promulgated three federal environmental statutes:

- Clean Air Act (CAA), August 2012, establishing new air emissions standards for hydraulically fractured gas wells and other oil and gas production activities
- Safe Drinking Water Act (SDWA), October 2012, that explicitly excludes the underground injections of any fluids other than diesel fuel used in hydraulic fracturing operations
- Clean Water Act (CWA), Spring 2013, addressing the problem of wastewater produced in natural gas extraction from shale formations and coal beds.

Gas as a low carbon bridge

On the other hand, shale gas development has important implications for the direction and intensity of national efforts to develop and deploy low-emission technologies. Shale gas has brought a significant improvement in the level of pollutant emissions by replacing some coal generation. Natural gas is a cleaner burning than its hydrocarbon rivals, emitting less CO2, particulate matter, sulfur dioxide, and nitrogen oxides, on average than either coal or oil.

Figure 39: Air Pollution Emissions by Combusted Fuel Type

Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Formaldehyde	0.750	0.220	0.221
Mercury	0.000	0.007	0.016

Source: EIA data

Therefore, domestic supply of natural gas can play a very significant role in reducing US CO2 emissions, particularly in the electric power sector. This lowest cost strategy of CO2 reduction should allow time for the continued development of more cost-effective or zero-carbon energy technology for longer term, when gas itself is no longer sufficient. This abundance of relatively low cost gas is providing US with a cost effective bridge to a secure and low carbon future (MIT, 2011).

3.3. Evolution of gas prices in Europe and Asia

Europe and Asia are the two regional gas markets with the highest price of gas. A decrease in the gas price in these markets would represent a step forward towards a unique gas price. This subsection analyses the evolution of the price in these markets taking into consideration the main drivers: supply, demand and, in the case of Europe, the power market of Russia, the primary gas supplier.

Europe gas demand is quite influenced by how the gas prices evolve in US, nowadays expensive gas being replaced by coal in power generation. Meanwhile, there is a strong demand of LNG imports in Asia regardless the shale boom: Japan is unsecured about its nuclear policies, South Korea targets to give up nuclear and China to shut down some coal fired plants, and all this to be replaced by gas fired generation. Therefore, in the last years gas demand increased all over the world, except Europe.

Natural Gas Consumption	2011 (bcm)	2011 share of total	% change, 2008-2009	% change, 2009-2010	% change, 2010-2011
US	690,1	21,5%	-1,6%	3,8%	2,5%
European Union	447,9	13,9%	-6,3%	8%	-9,9%
South and Central America	154,5	4,8%	-4,4%	11,1%	2,9%
Middle East	403,1	12,5%	3,7%	9,6%	6,9%
Africa	109,8	3,4%	-1,3%	8,1%	2,7%
Asia Pacific	590,6	18,3%	3,6%	12,2%	5,9%
China	130,7	4%	10,1%	20,2%	21,5%
Japan	105,5	3,3%	-6,7%	8,1%	11,6%
World	3222,9	100%	-2,5%	7,6%	2,2%

Table 4[8]: Natural Gas Consumption

[8] Source: (BP, June 2012)

Such an increase in the demand combined with a stable supply in the short and medium term will not be able to drive prices down, to achieve a convergence between Europe, Asian and US gas prices.

3.3.1. Supply

Given that the price drop in the US was highly influenced by the shale gas emergence, the present section analyzes the probabilities of exploiting such reserves in other parts of the world. Shale reserves are not only in US, but US has the experience in 'fracking' techniques and is a world leader in research on the potential adverse environmental consequences of this technology. However, technical recoverable shale gas resources are spread all over the world, and especially the regions in which gas price is high are willing to start exploiting. One might think that learning from the US experience, benefiting from their engineering techniques, might easier other countries' way towards exploiting shale gas. In fact, this path should not be taken for granted, as there might be a lot of differences that could hinder the straightforward way.

First of all, geology knowledge is very important for the development of shale gas production: where are located, how large the reserves are, how big. Although the US shale gas revolution only spans in the past decade, the very first attempt to develop shale gas deposits in the US dates back in the ninetieth century, almost 40 years ago. Therefore, US needed 40 years to understand their shale gas geology, crucial for reducing the extraction costs that lead to the success of the shale gas industry. No country has been investing for so long at this stage as US, therefore they are many years behind for having such good geology knowledge. Afterwards, the question to be answered is whether there are similarities in the geology structure between the US shale gas reserves and the others. If so, technology can be imported from US, but on the contrary, they have to follow the entire technology learning curve for achieving an economically recoverable reserve. On top of that, there are a number of external factors that favored the US in the shale gas revolution, which doesn't occur in most of the countries: proper regulation with favorable policies, high social acceptance, government support, competition between agents in the industry, the fact that the undergrounded space is private propriety, and a good infrastructure in general (pipelines, roads, water, suppliers).

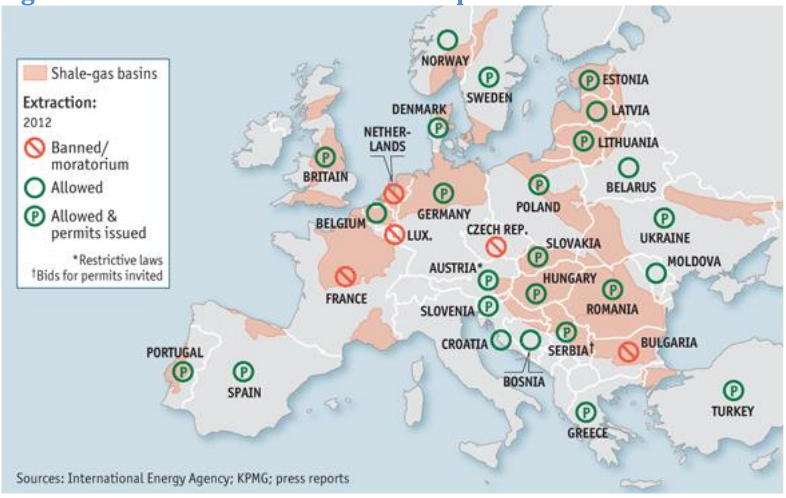
All these arguments sustain the fact that is unlikely to witness in the near future a new shale gas revolution in another part of the world. Nevertheless, there will be shortly analyzed the possibilities of shale gas exploitation in Europe, who makes considerable efforts towards gas price decreasing to gain industrial competitiveness, and in China, who detains the largest shale gas reserves in the world and could decrease gas prices in Asia.

Shale gas in Europe

The shale gas exploitation in US created an energy gap between US and Europe, affecting Europe's energy prices and competitiveness. Heavily depended on imports, caught between long term pipelines supply from Russia and LNG imports from Middle East, Europe is afraid not to miss out the shale gas revolution. The real potential of shale gas in Europe is not known yet, but the estimated production of shale gas would not exceed a total of 1,300 billion cubic meters, which is, over a production period of 25 years, barely five percent of what Europe consumes each year. Comparing to US shale gas which fulfilled 56% of the consumption in 2012, the shale gas doesn't seem to be able to bring the same revolution in Europe. In addition, the favorable external conditions of US are not present in Europe: the presence of a major oil and gas industry, the great empty spaces that has let the Americans drill more than 200.000 wells in just a few years, the fact that the subsurface rights are not hold by citizens but by the government, which makes it more difficult to be contracted by companies, and the much more stringent local regulations, including environmental policies (Feitz, 2013).

Therefore, progress is very slow regarding shale gas in Europe. With the exception of Great Britain, which recently lifted a moratorium in test drilling, all western European countries have suspended drilling for shale gas: Francois Hollande totally banned fracking in France during his entire mandate, The Netherlands and Luxembourg have also suspended drilling, Germany suspended fracking in September 2012 pending research on the risks involved and in Austria the cost of complying with environmental regulations makes shale gas uneconomic. In Eastern Europe, public disapproval is not as fierce, as Romania recently lifted its ban, Czech Republic and Bulgaria has in place a moratorium and in Poland shale extraction already started (The Economist, 2013). The environmental factor is the greatest hinder in the most of the European countries towards shale gas development. However, critics affirm there is a dozen of hypocrisy in that, since the share of coal increased significantly in the power generation mix in Europe. Lately, it makes much more economical sense to import cheap coal from US than to use expensive renewables or gas, even more that the price of EU emission allowances decreased a lot, as a consequence of the economic crisis.

Figure 40: Shale Gas Reserves in Europe



Source: (The Economist, 2013)

Therefore, it will be a long time before Europe can catch up with America: it takes time to assess whether shale gas exists in commercial quantities, then again it takes time before starting production and few years more until shale gas could provide a significant addition to suppliers: in total, more than ten years.

Shale gas in China

A study by Chinese Ministry of Land and Resources estimates that China has the largest proven reserves of shale gas worldwide (25.08 trillion cubic meters totally), nearly 200 times its annual gas consumption. The benefits that China could gain from exploiting these reserves are huge: reduce its reliance on coal as well as on LNG imports, reduce dramatically its CO2 emissions, accelerating thus China's transition to a resource-conserving and environmental friendly society. Even if China is in the nascent stage of shale gas development, it has set an ambitious goal of 6.5 billion cubic meter of shale gas production by 2015 as part of the 12th Five-Year Plan (2011-2015), and over 60 billion cubic meter of shale gas production by 2020 (Chang, Liu, & Christie, 2012).

China has, however, a hard time achieving this ambitious plan. Although it has a huge amount of shale gas reserves, many of them are kept in a geological structure that is hard to extract. At the same time, China lacks broad pipeline gas network, professional labor for this area and the technology for its complex geological conditions. At present, shale gas exploitation is based on hydraulic fracturing which needs a lot of water, and maintaining enough water supplies is an inevitable obstacle for China. For such countries with poor water resources, the way to success is to choose an area with relatively rich water for test and actively develop recycling technology. As well, large investment funds are needed. According to the Deputy Director of Oil and Gas Resource Strategic Research Centre, in order to achieve the goal for 2020, China needs to dig 20.000 wells and to invest in the next 10 years around 95 billion dollars. Even if China is a country that benefits of sufficient government support when a goal is set, they don't have the know-how and the R&D sources for such an industry (Xingang, Jiaoli, &Bei, 2012).

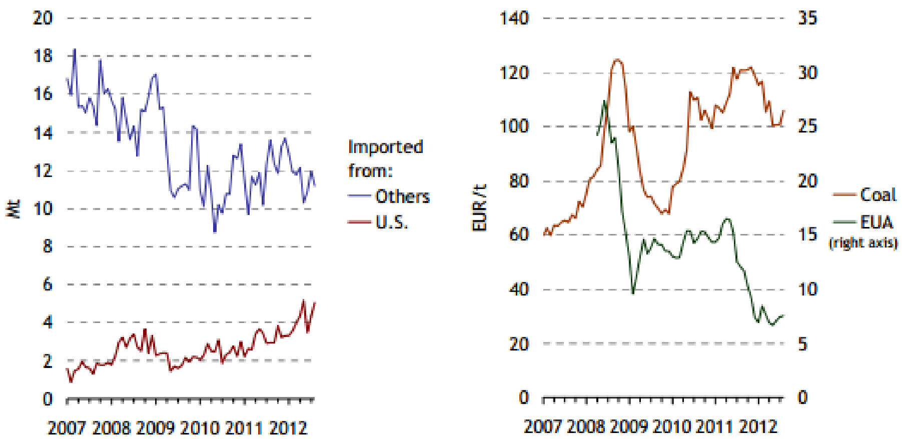
3.3.2. Demand

Gas Demand in Europe

Even if arbitrage is not straight forward between major regional gas markets, the events in one market impacts to some extend the other markets. For example, shale gas revolution in US triggered a globally shift in gas demand, affecting especially Europe. Just five energy consuming industries – chemicals and petrochemicals, non-metallic minerals, food and tobacco, iron and steel and paper, pulp and print – are responsible for more than 25 percent of European natural gas consumption. If some of those industries were to relocate, natural gas demand would shift (ReinhildeVeugelers, 2013).

Europe witness at the moment a decrease in the gas consumption in power generation mix, substituted by the surplus coal exported from US. The near-collapse of Europe's emissions-trading scheme means there is no realistic carbon price to reward the green advantage of gas over coal in power generation.

Figure 41: Coal imports by EU (left) and Coal import price of the EU and EU emission allowance price (right)



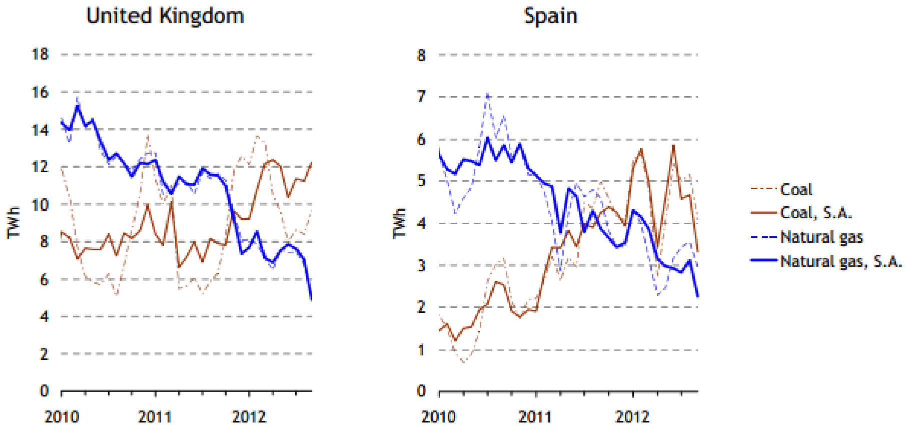
Source: Eurostat

Source: Eurostat, IntercontinentalExchange

Source: (Yanagisawa, 2013)

For instance, UK has reduced natural gas power generation sharply since autumn 2011 and increased coal generation instead. The same happened in Spain, where coal generation used to be less than half of natural gas power generation, in 2012 it exceed natural gas power generation.

Figure 42: Natural gas and coal power generation in the UK and Spain



Source: Calculated from U.K. Department of Energy and Climate Change

Source: Calculated from Red Eléctrica De España, "Boletín mensual"

Source: (Yanagisawa, 2013)

Another impact of low gas prices in US is upon the oil global market. If prices in US are going to maintain themselves low, the gas demand will keep rising, replacing, where is possible, also the oil consumption (power generation, some industries). Therefore, oil demand will decrease, and as oil market is global, oil prices would likely decrease. Consequently, lower oil prices might replace gas consumption in other parts of the world.

Along with the gas based industries shift towards US (discussed in Chapter 4: The reindustrialization of the US market), a shift in gas demand will take place from Europe and Asia towards North America.

All in all, EU's gas demand already decreased by about 10% in 2011, being the largest recorded decline, and by further 2.3% in 2012.

Gas Demand in Asia

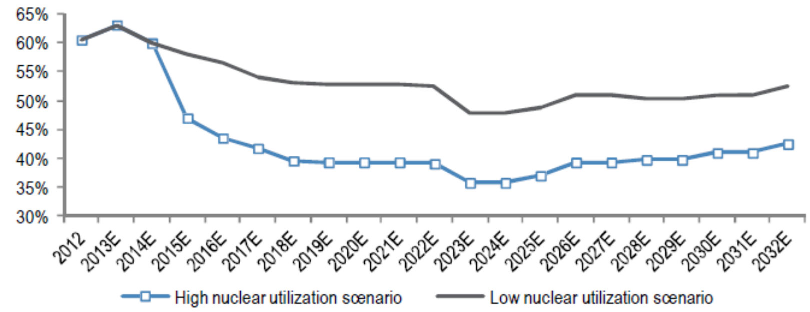
Japan

One of the most important drivers and variables of gas demand in Asia is the power generation sector in Japan. The earthquake and the Fukushima nuclear disaster in March 2011 had a great impact on the LNG demand. Fifties of the Japan's nuclear reactors have been shut down and oil and coal fired power plants were damaged. Therefore Japan sought to replace all this lost capacity with gas-fired units.

The fact that since the Fukushima disaster only two reactors had been restarted, and the continued rollout of new gas fired electricity generation (Osaka Gas doubling its fleet of gas fired generators and TEPCO looking to replace some of its lost Fukushima capacity with natural gas) together with the continuing recovery of Japanese manufacturing sector, forecast the persistence of the same strong LNG demand (J.P.Morgan, 2013).

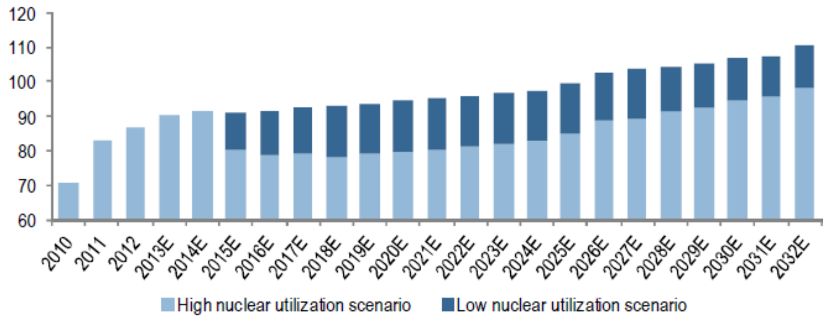
LNG imports strongly depend on the decision of restarting or not other nuclear reactors. Figure 43 below shows the utilization rate of gas-fired thermal power plants in both scenarios, of high nuclear utilization scenario and of low nuclear utilization scenario, while Figure 44 illustrates the differences in LNG demand under the same two scenarios.

Figure 43: Utilization rate of gas-fired thermal power plants



Source: (J.P.Morgan, 2013)

Figure 44: LNG demand in Japan

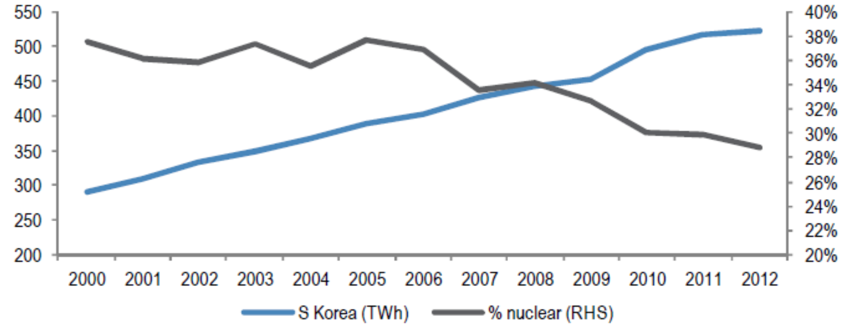


Source: (J.P.Morgan, 2013)

South Korea

South Korea calls for reduction in nuclear reliance as there is considerable popular opposition to nuclear power since the Fukushima incident in 2011. Therefore, comparing to the previous long term plan that called for 41% nuclear power by 2030, the new long term energy plan due out in December 2013 should target 22-29% nuclear power contribution by 2035. Nuclear power accounted for 29% of South Korea's electricity generation in 2012. Assuming 3% annual growth in South Korean electricity demand and assuming that the reduction of nuclear is to be filled by gas-fired generation, the difference between the former 41% nuclear contribution and the new target is translated in a considerable increase in LNG demand (J.P.Morgan, 2013).

Figure 45: South Korea total electricity consumption, % of nuclear mix

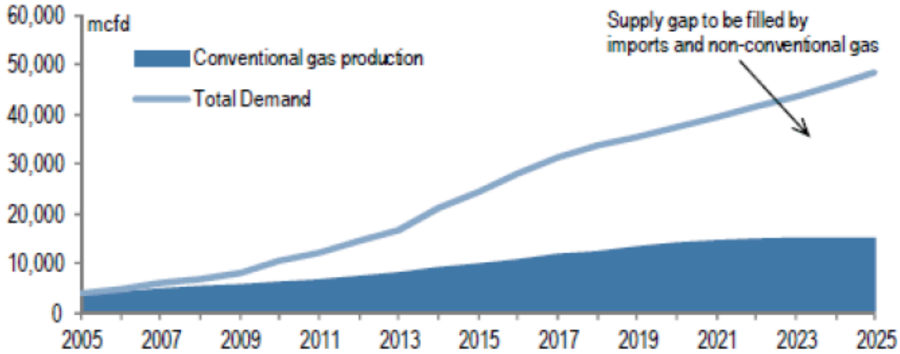


Source: BP statistical review

China

On the other hand, China is struggling to phase out coal fired generation. Municipal authorities in Beijing have outlined a proposal to shut down the city's four remaining coal-fired power generation facilities until 2015 and replace the lost capacity of 2.7GW with 7.2GW gas-fired generation. China also set a target to increase the contribution of gas in primary energy mix from currently 5% to 10%. This increase translates in increasing LNG import, pipeline imports and domestic unconventional gas.

Figure 46: Forecast Chinese natural gas demand vs. conventional production



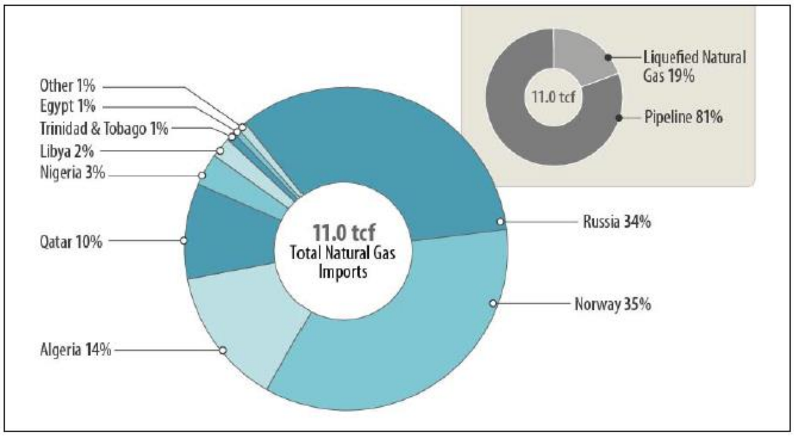
Source: Wood Mackenzie, J.P Morgan estimates

3.3.3. Power market of gas suppliers (Russia)

Being highly dependent on imports, Europe and Asia are price takers in the natural gas trade. Both importers try to diversify as much as possible the natural gas supplier, so as to diminish their market power. Historically, Europe was highly depended on gas from Russia, which was exporting through pipelines gas on oil linked priced long term contracts and under the controversial clause "take or pay". This section is dedicated to the inevitable decrease that Russia suffers in its market power upon the gas market in Europe, which could strongly influence the gas prices.

Russia is currently the dominant supplier of natural gas to Europe, accounting for around 34% of the EU's gas supplies. However, the dependency doesn't go only in one direction, Europe being the most important market for Russian natural gas exports, half of its exports being towards Europe.

Figure 47: EU Natural Gas Imports



Source: (Ratner, Belkin, Nichol, & Woehrel, 2013) based on BP Statistical Review on World Energy 2013

In the future, Russia may have to compete with a lot of new gas suppliers that are interested in selling gas in Europe. Central Asia and North Africa hold great potential to produce more natural gas than they currently do, and given the proximity of both to Europe. it offers possible alternatives to Russian supply: Azerbaijan is growing its gas exports targeting the Turkish and European market, Kazakhstan is a new natural gas net exporter, Turkmenistan, with the fourth largest conventional gas reserves, is interesting in exporting gas to Europe, and Uzbekistan appears to have sufficient gas reserves to become a potential supplier of Europe if its infrastructure will allow. In North Africa, Algeria, Egypt and Libya are already supplying Europe with gas both through pipeline and LNG but due to changing regime in Egypt and Libya's intention to promote expanded development of natural gas resources, exports might increase in long term (Ratner, Parfomak, Fergusson, & Luther, 2013).

Also new perspective of LNG imports appeared for Europe: US is currently redirecting its previous contracted LNG imports to Europe and soon it will have its own LNG exports from shale gas. On top on this, Europe is seeking to exploit its own shale gas resources and new conventional off-shore gas resources were found in Romania, Bulgaria and the east of Mediterranean Sea. Gas imports share from Russia to Europe have already declined in the last two decades from 60% to 40% (Umbach, 2013).

Therefore, there is a strong rational for Russia to offer gas to Europe under more flexible condition and less priced, as otherwise, along with diversifying its suppliers, Europe has strong incentives to invest in off shoring energy intensive activities to low-energy cost regions, to invest even more in energy efficiency and in replacements for natural gas. Clearly Russia is losing market power in Europe, and it has to either reduce the export gas price or its market share will suffer even more. Others of Gazprom's competitors, like Statoil, have renegotiated many of their long term contracts to spot price indexation. However, Russia losing power market in Europe doesn't directly imply a gas price reduction.

3.3. Transportation barriers of LNG trade

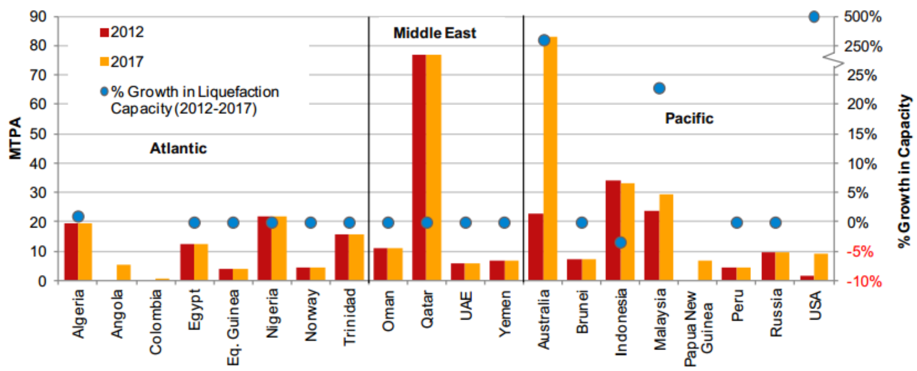
The dynamics of gas markets, emergence of supplies in some regions, increasing demand in other region, all these foster the growth of the LNG spot market. An increase in LNG trade between the main three regional gas markets is the most probable solution for achieving a global gas market and price. However, compared to oil, transportation and storage gas is still expensive, which limits the link formation between the markets.

Currently, global LNG market is in a stage of relatively infancy, serving only 10% of the global gas consumption. However, the recently discovered shale gas reserves in US and Australia and the increasing demand and high prices gas imports in Asia and Europe determines the development of this market in the near future. Still, sufficient arbitrage won't be achieved in order to lead to a fast price convergence between regional markets.

3.3.1. LNG Supply

In the next 5 years one new supplier will emerge on the LNG market- United States, which will increase five times more its liquefaction capacity- and two other will significantly intensify their exports- Australia and Malaysia. Australia will exceed Qatar in the amount of liquefaction capacity, becoming the greatest supplier. The rest of the suppliers will maintain its current liquefaction capacity.

Figure 48: Liquefactions terminals by capacity and country



Source: (IGU, 2013)

The new LNG Supplier: North American LNG opportunities and impacts on the global gas market

The table below illustrates the additional costs to be added to the Henry Hub price in order for American shale gas to reach Europe and Asia.

US $/MMBTU	Europe		Asia	
Source	NERA Study[9]	Oxford Institute[10]	NERA Study	Oxford Institute
Liquefaction in US	2.34	3	2.34	3
Transportation from US to	1.27	1.3	2.54	3
Regasification in	0.86	0.4	0.91	0.4
Total additional cost to HH	**4.47**	**4.7**	**5.79**	**6.4**

Table 5: Prices for Gas Liquefaction, Transportation and Regasification in Europe and Asia

Henry Hub Price	Final LNG Price for Europe	Final LNG Price for Asia
US $/mmbtu		
4	8.47 -8.7	9.79 -10.4
5	9.47 – 9.7	10.79 – 11.4
6	10.47 – 10.7	11.79 – 12.4

Table 6: Final LNG Price for Europe and Asia

Figure 49: World LNG Estimated November 2013 Landed Prices

Source: (Federal Energy Regulatory Commision, 2013)

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[9](NERA, 2012)
[10](Henderson, The Potential Imapct of North American LNG Exports, 2012)

The initial conclusion after analyzing the possible LNG landed prices from US is that both Europe and Asia are attractive destinations. If Henry Hub price will be maintaining in medium term in a range between 4 and 6 $/MMBtu, the final LNG price to Europe would be between 8.5 and 10.7 $/MMBtu, while currently Europe is buying LNG for 10.66 $/MMBtu (UK) and 10.9 $/MMBtu (Spain). For a Henry Hub price of 6 $/MMBtu, exports to Europe doesn't guarantee to US any margin, therefore only for Henry Hub prices of maximum 5$/MMBtu the exports to Europe would make economic sense.

However, in Asia the commercial argument appears even more compelling, as even with a maximum Henry Hub Price of 6 $/MMBtu, the current theoretical landed cost of gas would be between 11.8 and 12.4 $/MMBtu, assuring a margin of more than 3 $/MMBtu if exporting to Japan and Korea and around 3$/MMBtu for exporting to China. In the most optimistic case of a Henry Hub price of 4 $/MMBtu, the margin range for exporting in Japan and Korea would be between 5.25 and 5.85 $/MMBtu.

It is therefore clear that US exports to Asia appear much more attractive than the ones to Europe, especially at higher Henry Hub prices for which exports to Europe exceeds the current gas prices there. As a result, it appear that the likely impact of US exports on Europe in terms of volumes could be rather small, with a limited price impact relative to current levels.

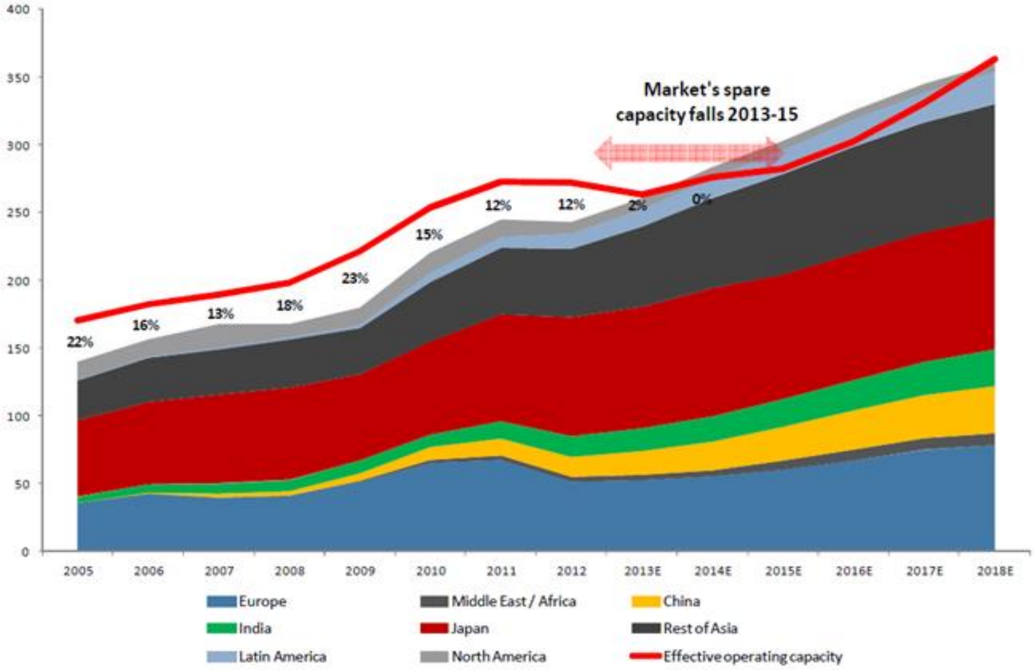
On the other hand, US exports to Asia might have a greater impact, depending on when the North American gas can actually arrive in Asia. There is a consensus among industry specialists that there will be an LNG supply shortage between 2013 and 2015, until new projects come on-stream. Therefore, if US LNG arrives in Asia during this shortage, it would simply satisfy the demand, with little less price impact. However, the bulk of North American gas exports are scheduled after 2016, and the impact on Asian spot prices could be more dramatic, despite the large share of demand that has already been tied to long-term contracts. The impact of US LNG imports is most likely to be on spot prices and on the contracts with significant take-or-pay options included. There is also the possibility of renegotiating the long-term contracts if the price differential between oil-linked and gas market related prices remains wide. Despite the country's concern over the security of supply that could mitigate a shift in LNG price formation mechanism from oil-linked contracts to market based price, a price re-negotiation as in Europe cannot be totally discounted.

Due to all the additional costs to be added to the wellhead price, the liquefaction, transportation and re-gasification costs, the final price won't be low enough to make a price impact as dramatic as might be suggested by the current price disparities. Nevertheless, US export could have an important role to play in changing the way consumers consider gas price formation across the globe, as the interaction between markets where gas-to-gas competition is prevalent with markets based on oil-linked pricing is already causing disruption in price negotiations (Henderson, The Potential Impact of North American LNG Exports, 2012).

An aspect that could totally change the import scenarios in Asia from US is the possible gas imports from Russia or the potential domestic shale gas production in China. In this situation, the extra supply from closer markets, and at lower prices, might cancel the economic margin of US exports. Secondly, US exports might have a great impact on the gas volumes flow. If North American LNG arrive in Asia it could displace some Middle East and African sourced LNG, which would be redirected most probably towards Europe.

3.3.2. LNG Demand

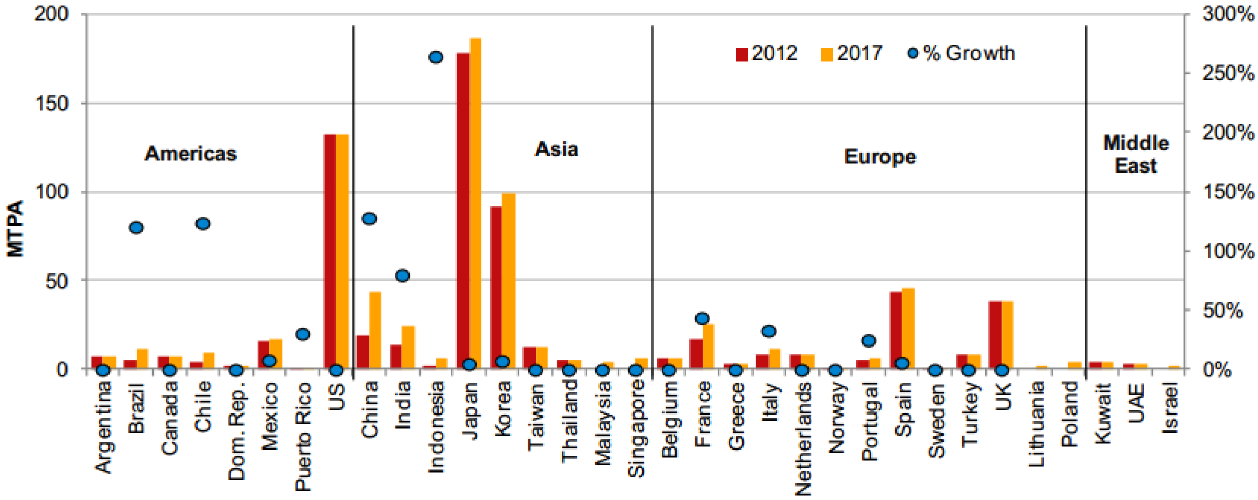
Figure 50: LNG Demand Forecast



Source: (J.P.Morgan, 2013)

Figure 50 illustrates the LNG demand around the world. Europe is willing to buy more LNG in order to diversify its gas supplier and to decrease dependency of Russia. An important LNG demand increase will take place in China, resulting from its efforts to reduce coal fired generation. The economic growth in India will demand as well significant LNG imports. Japan will continue to be the most important LNG buyer in the global gas market, followed by the rest of Asia (especially Korea and Taiwan). Latin America will also increase dependency on LNG imports, as the emerging markets, Brazil and Chile, will expand regasification capacity. New markets will need to assess the risks of launching terminals without firm commitments for long-term supply. Even if this is a non-traditional strategy, developing such projects might help these countries' short-term or seasonal energy requirements.

Figure 51: Regasification terminals by capacity and country



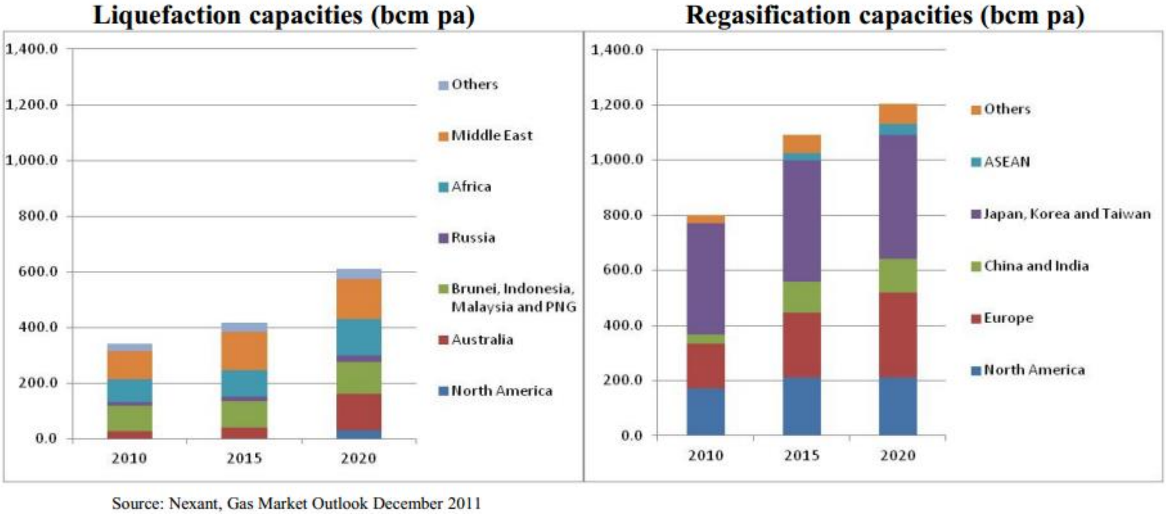
Source: (IGU, 2013)

Figure 51 illustrates the capacity of regasification terminals in each country existent in 2012 and planned for 2017. On the American continent the LNG imports will intensify in Brazil and Chile. While US has a huge amount of LNG import capacity, most of them are projected to be transformed in liquefaction plants. In Asia, China, India and Indonesia will increase their LNG imports, while Japan and Korea will maintain their position of the largest LNG buyers in the world. Trying to diversify its suppliers, Europe will increase imports in France and Italy, but Spain and UK will remain the main LNG importers.

3.3.3. LNG Trade

Over the past decade both global liquefaction and regasification capacity increased significantly, resulting in a more and more developed LNG market. The rise in liquefaction capacity was led by a massive expansion in the Middle East as a result of the construction of major projects in Qatar. In the future, the boost will be given by the new exportation plan of US and Australia. Comparing to liquefaction terminals, global utilization of LNG import terminals has historically been much less, due to the seasonal nature of many gas markets as well as the variations in demand worldwide. Utilization fell to 37% in 2012 both as a result of decreased LNG supply and slumping demand for LNG in Europe and North America, which left many terminals empty.

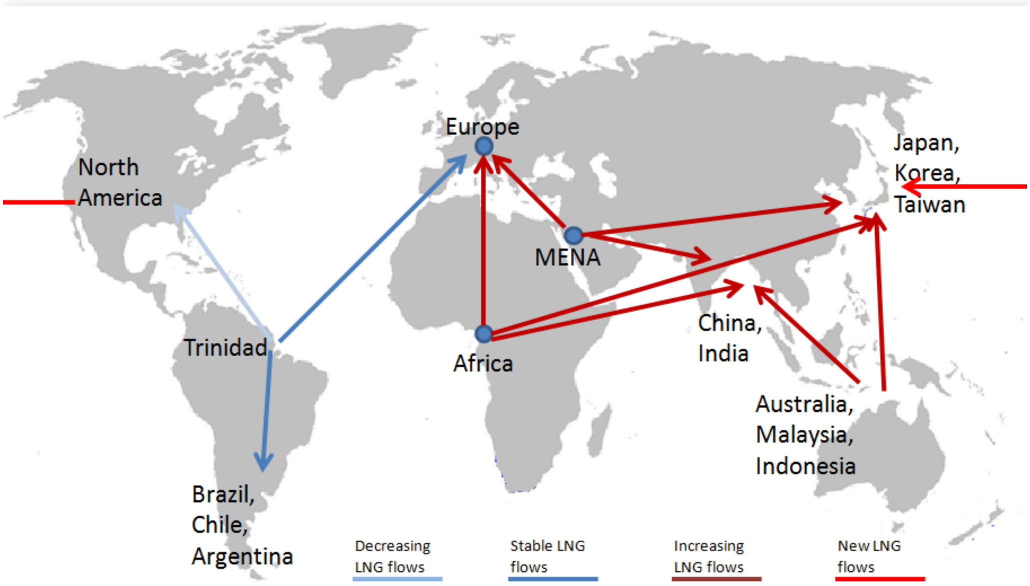
Figure 52: Liquefaction and Regasification Capacities in 2010, 2015 and 2020



Source: (IGU, 2013)

Given the LNG liquefaction and regasification terminals under construction, there can be estimated how the global LNG trade will change over the next 5 years. LNG flows will increase especially in the Pacific basin and Middle East basin: Australia and Malaysia are becoming important suppliers and China and India will significantly increase their imports. United States will emerge as an important member on the LNG exporter maps, targeting Asian market, especially the high gas prices in Japan. LNG trade is expected to remain stable in the Atlantic Basin, as the US will prioritize the exports to Asia. Significant changes will take place in the Mediterranean Sea, due to increasing exports from MENA (Middle East and North Africa) to Europe.

Figure 53[11]: LNG Trade changes from 2012 to 2017



[11] Own elaboration based on data from (IGU, 2013)

Conclusion

The chapter analyses the drivers and constraints in achieving a global gas price, taking into consideration the regional supply, demand, price formation mechanisms and future LNG trade.

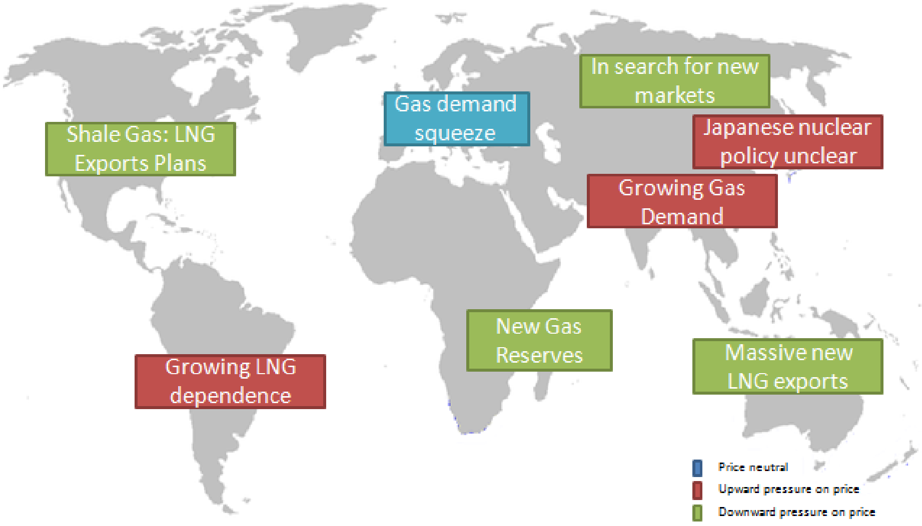
On one hand, increased demand in most of the economy sector in US might drive gas prices up, but on the other hand the abundance domestic supply at relatively low cost keeps gas prices low. Other factors as future LNG exports and environmental regulations are unlikely to strongly influence the domestic prices. It is true that natural gas prices cannot persist at levels as low as $2/MMBtu, but supply and demand will nevertheless balance at a lower price compared to prices abroad.

While Europe might miss the shale gas revolution, its demand is slightly decreasing as a result of chemicals industry shift to US and of coal replacing gas in power mix generation. Europe tries to decrease dependency of Russian gas and to shift from oil linked gas contracts to a gas on gas competition price, by importing spot LNG and by developing trading hubs.

Asian gas demand is maintained at high levels due to anti-nuclear policy to be adopted in Korea, Japan and Taiwan. This, their concern for security of supply and the vertically integrated monopolies in the industry will keep prices high. Nevertheless, the shale potential in China and new exports from Australia, in addition to possible exports from Russia, who is searching for new markets, might equilibrate prices.

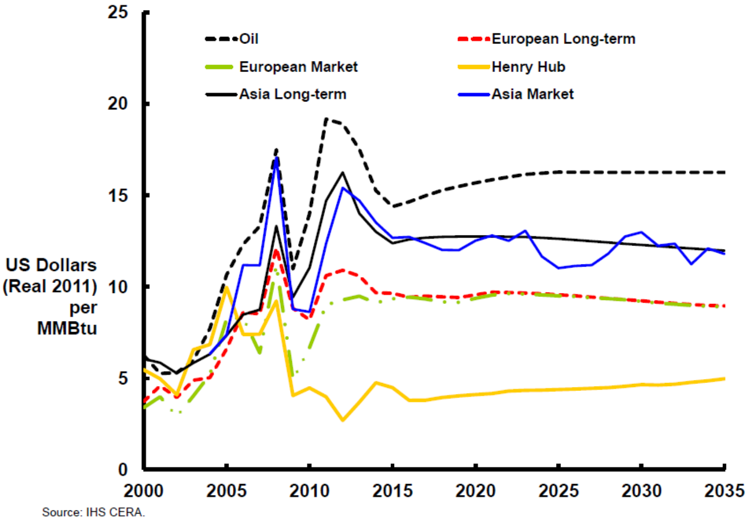
However, the pressure between regional gas price differentials is growing as growing LNG trade will make arbitrage between markets easier. The greatest impact that US LNG exports will have in the first stage is to introduce the Henry Hub linked prices in Asia, where oil-linked contract prices prevail. While the introduction of North American gas exports may not have as dramatic impact on global gas prices as expected, it could significantly change the way in which prices are negotiated.

Figure 54: Regional pressures on gas price



As observable, there are markets that are pushing gas prices up, whereas others are pushing it downwards. However, a global gas price won't be reached unless substantial trade between the markets will link them. In gas industry, the transportation barriers are relatively high, which makes it difficult for prices to converge soon.

Figure 55: Long Term Price Outlook



Source: IHS CERA

Part II Natural Gas Industrial Competitiveness

Fourth Chapter: Industry's dynamics as a consequence of natural gas markets competitiveness

> ***"Such is the impact of the shale gas revolution in the United States that it's quite possible that babies born today will no longer play with plastic dolls and cars made in China." (Washington Post, 2013)***

Introduction

The first part of the dissertation provides an overview on the prices in the regional gas markets worldwide and analyses whether a global, more uniform price will occur in the short and medium term. The present high price differences between markets and the fact that this situation is not just a transitory trend, creates significant competitive advantages for the gas based industries in regard to their location. The North American market, with relatively low gas prices and abundant gas supply, provides the gas based industries a great advantage comparing to the European, Asian or Brazilian market.

Competitiveness is a fuzzy term used to mean many different things. McKinsey Global Institute defines competitiveness as a capacity to sustain growth through either increasing productivity or expanding employment. A competitive sector is one in which the performance can be improved by increasing productivity and offer better quality or lower-priced goods or services, expending thereby the demand (McKinsey Global Institute, 2010).

The present chapter studies the impact of natural gas price to the industry's dynamics. The first section will define the main usages of natural gas and its role in the industrial competitiveness of a country. Following, a next section will address the question of which are the most industrial competitive markets from natural gas' perspective. Analyzing the gas markets through the perspective of gas price, gas availability and political risk, United States is today the most appealing market for the gas intensive industries. This conclusion is to be sustained by the third section, which presents the impact of the shale gas boom and the natural gas prices drop upon the US industry. This process is called the re-industrialization or the re-shoring of the US market. Last section identifies other factors able to increase the industrial competitiveness of a country, factors that could make the difference in the context of a more uniform gas prices.

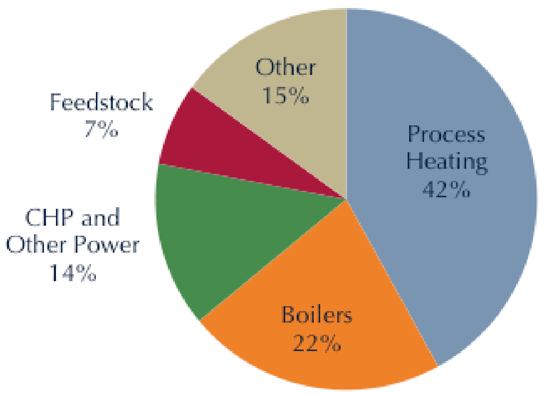
4.1. The industrial competitiveness and the role of natural gas in it

In the present study, the industrial competitiveness of one country is treated as the ability of the industry or of an industrial sector to create an advantage upon the same industry or industrial sector of other country, resulting thus in economic growth, higher contribution of this sector to the GDP and foreign investment. In a globalized world, competitiveness of a sector allows an industry to maintain and improve its position in the global market.

An important factor contributing to increasing competitiveness in some sectors of the industry is the cost of energy. Being essential for any form of economic activity, energy have characterized industrialization and economic development process over the last past century (Warr&Ayres, 2010). There is strong and well proved correlation between energy and long-term economic growth and development. Natural gas is a key energy source for the industrial sector and for electricity generation in a majority of countries in the world.

Natural gas represents a very important and growing part of the global energy system. Over the past half century, natural gas share has been growing with around 9%, from 15.6% of global energy consumption in 1965 to 24% today. Industry is the largest consumer of natural gas, accounting for 43% of its use across all sectors. Natural gas is consumed primarily in the paper, metals, chemicals, petroleum refining, stone, clay and glass, plastic & rubber products, iron & steel, aluminum and food processing industry. These businesses account for over 84% of all industrial natural gas use. Total industrial natural gas use involves heating and cooling process, electricity generation (fueling boilers and turbines) and feedstock for chemical products, fertilizers, plastics and other materials.

Figure 56: Natural Gas Use in Industrial Sector worldwide

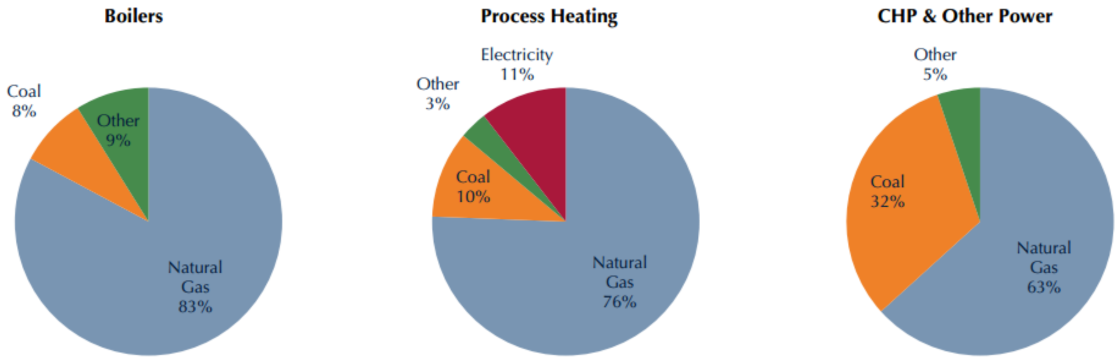


Source: (EIA, 2011)

The largest use of energy by the industrial sector is for process heating, used to heat raw material inputs during manufacturing. Natural gas is the dominant fuel used to generate heat, accounting for 76% share in the fuel mix for process heating.

An important usage of natural gas is to generate electricity. The most basic natural gas-fired electric generation consists of a steam generation unit, where fossil fuels are burned in a boiler to heat water and produce steam that then turns a turbine to generate electricity. Industrial boilers are used for a variety of purposes by chemical manufactures, food processors, pulp and paper manufactures. 83% of boilers run on natural gas. Another way of producing electricity from natural gas is by coproducing heat and power from a single unit with CHP (combined heat and power) technology. In 2010 in US, 14% of natural gas used in manufacturing was consumed by CHP and other power systems.

Figure 57: Direct Consumption of Fuels in the Industrial Sector worldwide



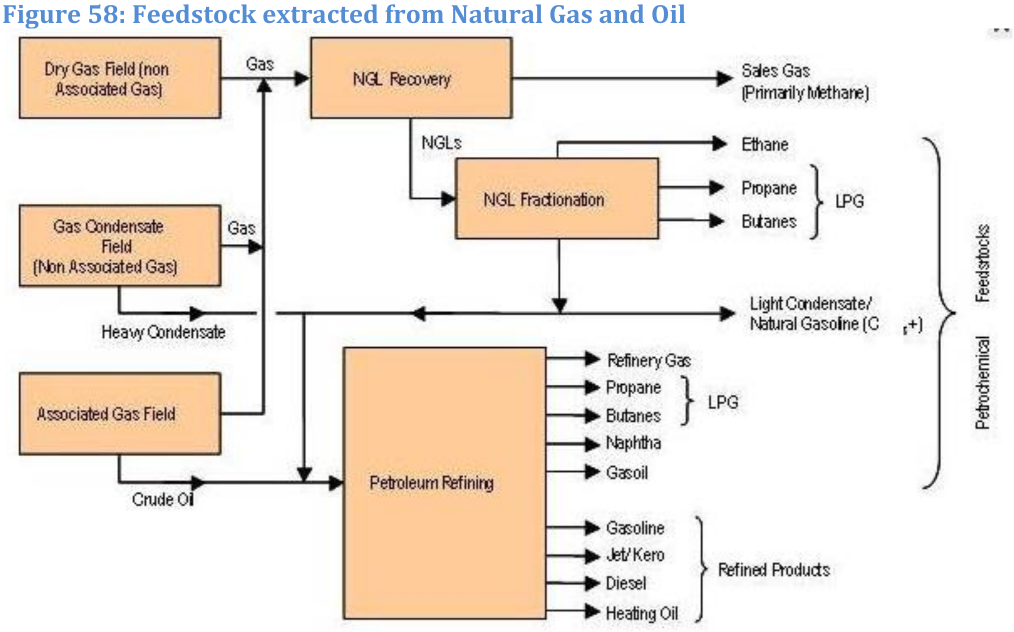
Source: (EIA, 2011)

Natural gas performs in the power sector a unique function, being able to provide both base load power and the system flexibility required to meet variation in power demand and supply for intermittent sources. Therefore, the low-carbon emissions and a low capital cost of natural gas generation compared to other fossil fuel generation, combined with abundant gas supplies and relatively low prices, make natural gas an attractive option and significantly contribute to increasing industrial competitiveness of the gas-based sectors in a carbon-constrained environment.

Historically, because of its higher fuel price compared to nuclear, coal and renewables, natural gas has typically had the highest marginal cost and has been dispatched after other generating units, setting thus the clearing price for electricity. The important technological development of CCGT plants was able to change the role of gas in power generation, increasing its share in the electricity mix. When in addition there is abundant supply at relatively low cost, the expansion of natural gas as a fuel for electricity could be even greater, with important microeconomics effects. In the cost structure of the electric power generation, fuel costs account for approximately 40% of the total production costs.

Natural gas has an even much larger part of the total costs in the petrochemicals industry. Here, besides being used as a fuel, natural gas serves a unique function, providing feedstock in the form of methane and other liquids, such as ethane, propane and butane. Chemical companies are particularly heavy users of natural gas as a feedstock and may consume up to two-thirds of their delivered natural gas in this purpose (Center for Climate and Energy Solutions, 2012).

Figure 58: Feedstock extracted from Natural Gas and Oil



Source: NexantInc, 2011

Having such a large utilization area, being both an important raw material in many industries and an important fuel for power generation, natural gas is a valuable resource, being able to influence, to some extent, the welfare of a country. Available and cheap natural gas can increase, firstly, the output of the manufacturing industries, which in turn creates more jobs, additional output in their supplier or indirect industries. The output of these supplier industries would rise and, combined with all added outputs of the supplier sectors, the economy will lead to billions of additional economic output (American Chemistry Council, 2012).

Natural gas price is therefore an important factor for a number of industries, for which it accounts for a large share of the cost structure. It is expected that cheap gas can foster the competitiveness of the sector, but the price is not the only factor that creates industrial competitiveness.

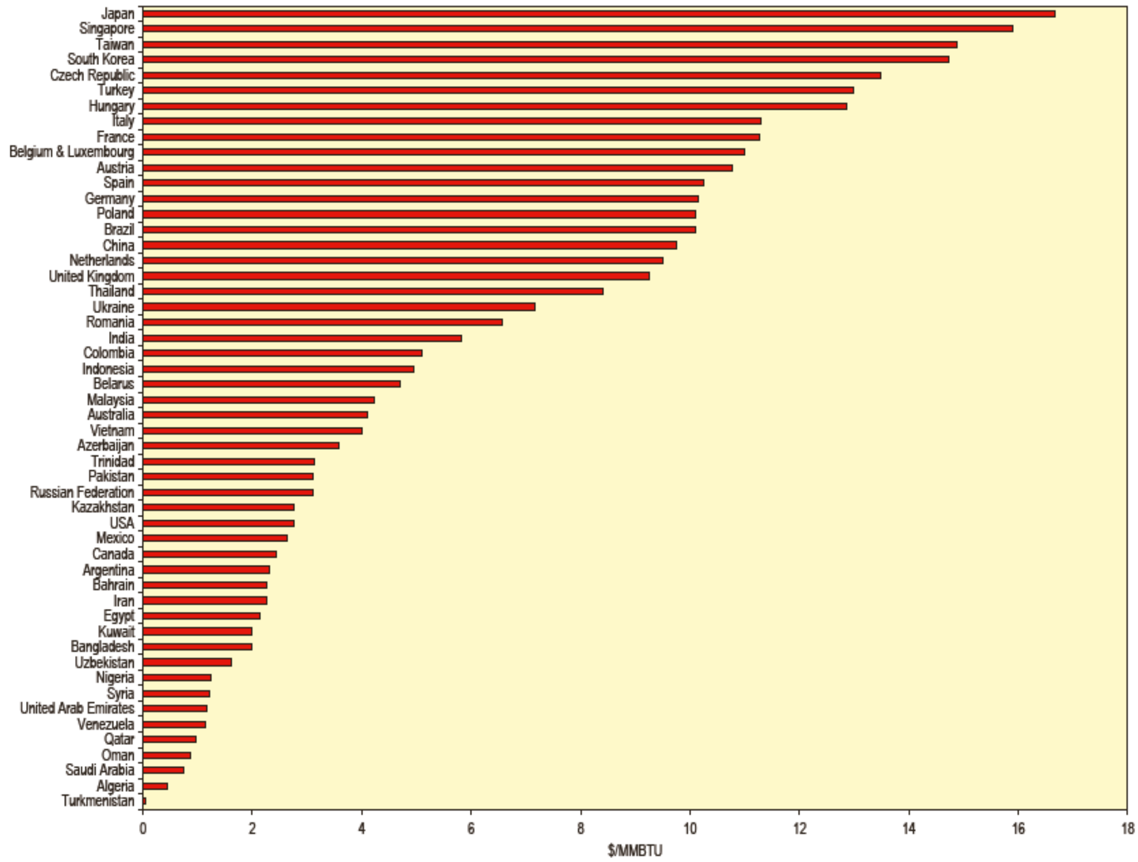
4.2. The criteria for industrial competitive markets

The present section identifies the most outstanding criteria that can influence the competitiveness degree: gas price, gas availability and political risk. The presence of both cheap and available gas, in certain markets, complemented by a relatively political secure environment could bring a significant competitive advantage for the gas based industries. However, it is important to mention that the compliance of these three criteria in a market doesn't imply an industrial competitiveness for granted. As the analysis will show, there are a lot of other aspects that can cancel the advantages brought by cheap gas, as well as there can be other favorable aspects that are able to overcome the absence of it, for example.

4.2.1. Gas Prices

Resource-intensive industries, such as gas industry, are typically tradable-commodity business that requires substantial up-front capital investment. The gas price is the major cost factor and an important element in measuring the sector competitiveness.

Figure 59: Average 2012 Wholesale Gas Price by Country



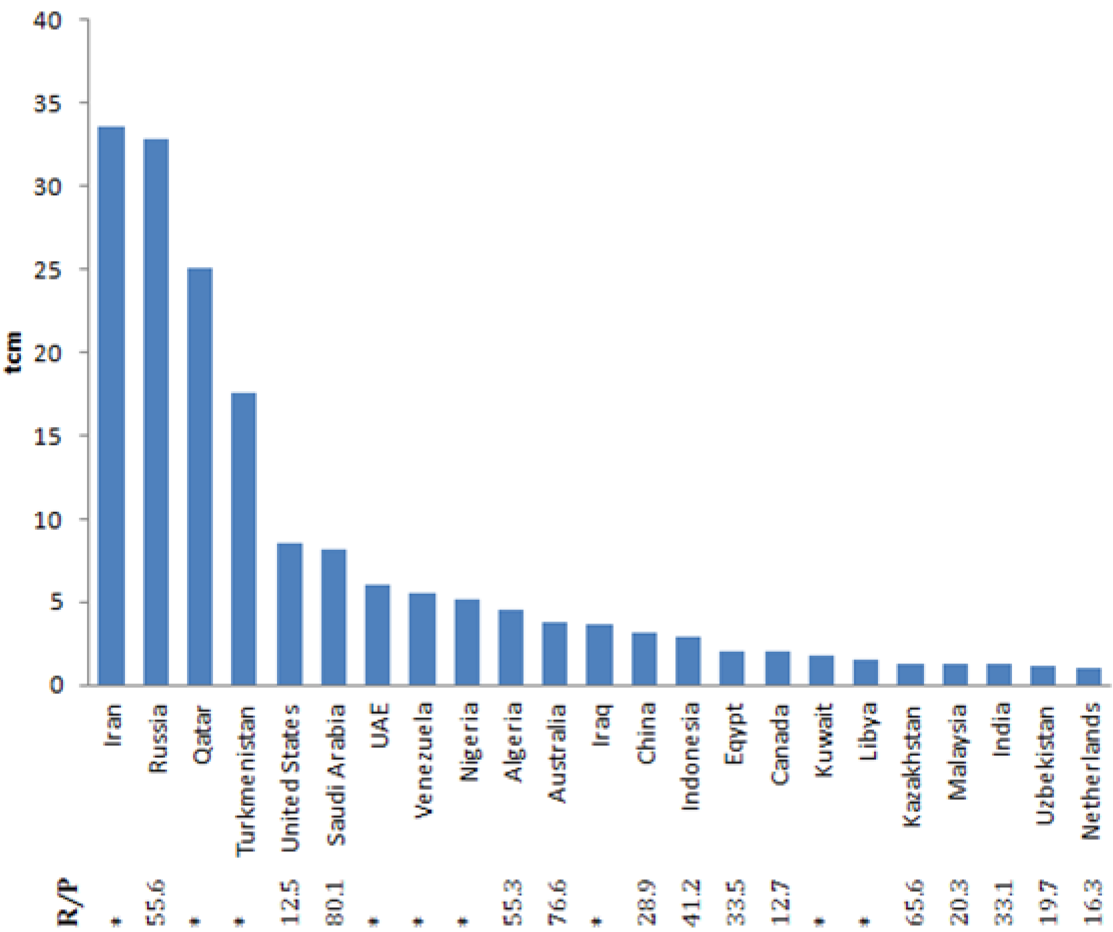
Source: IGU Gas Price Report 2012

Figure 59 was published in the latest report released by IGU on Wholesale Gas Prices and it presents the average wholesale gas price in a number of countries. As it can be observed, gas prices are ranged from few cents per MMBtu in countries in Africa and Middle East to \$17/MMBtu in Japan.

4.2.2. Gas Availability

Low gas prices don't help to the industrial competitiveness if there are no sufficient reserves and new production to supply current and new potential industrial consumers.

Figure 60[12]: Top Natural Gas proved reserves and Reserves to Production (R/P) Ratio,2012



Data Source: (BP, June 2013)

Figure 60 presents the first largest natural gas proved reserves in the world in the end of year 2012 and their reserve to production ratio.The reserve to production ratio divides proved reserves by the year's rate of gas production and is commonly used to estimate a resource's static lifetime, or the length of time the proved reserves will last assuming a steady production rate. This ratio helps the present analysis, by identifying the countries in which new production is available to supply the potential new industrial consumers. A very high ratio indicates that the production has room to grow. However, a too high ratio

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[12]* More than 100 years

can indicate some problems in putting reserves into production, such as the absence of a market or the lack of money to be invested in it. For example, despite the huge gas reserves in Venezuela, the country doesn't produce sufficient gas to supply new consumption. Hence, the R/P ratio is greater than 100 years because the annual production is very little. As it can be observed, gas reserves in US are higher than in Venezuela, but with an R/P ratio of only 12.5 years. This drives to the conclusion that production in US is very high, and able to supply a larger market.

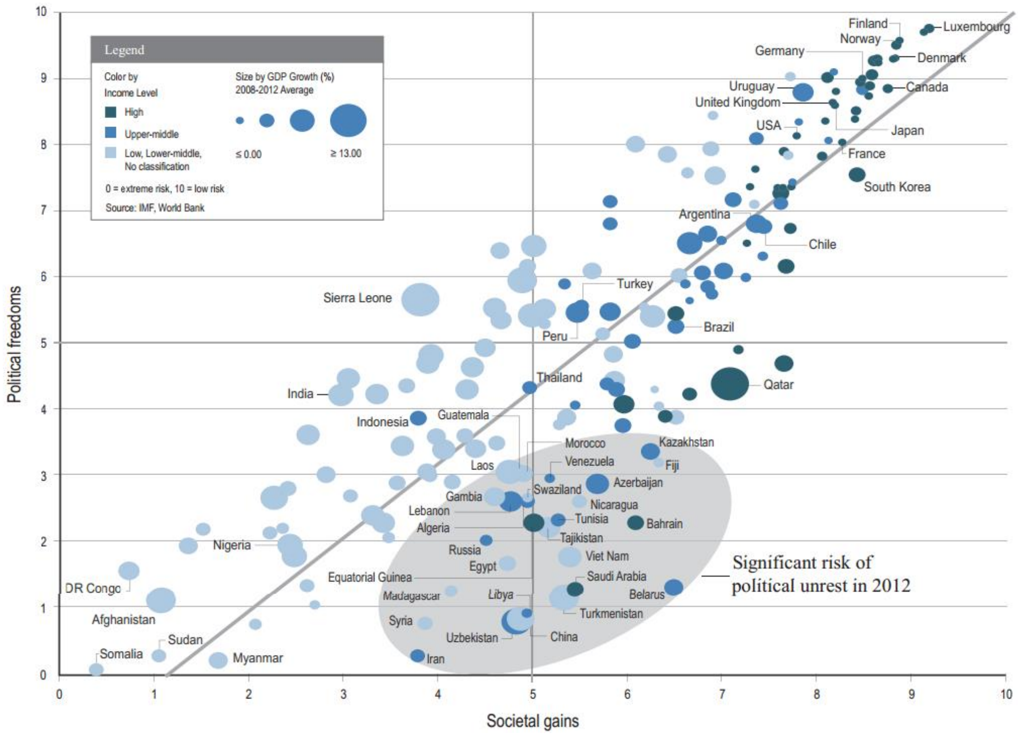
Russia holds the largest natural gas reserves in the world and as well its production is very high, being the only one in the first four largest gas reserves that has a R/P ratio less than 100 years (55.6 years). Even if its gas price was historically low, it increased considerably in the last 2 years. Since 2006, President Putin introduced the target of industrial gas prices reaching netback parity with the export prices in Europe. Therefore, the prices are following an increasing trend and Russia won't benefit much longer from the cheap gas. Natural gas price in Russia increased from less than 3 $/MMBtu in 2010 to almost 3$/MMBtu in 2012, exceeding the prices in US. Besides that, what have been keeping so far industries away from Russia are its high levels of political risk, reflecting its effectively authoritarian government and, accordingly, high levels of political interference in the key sectors. High oil and gas revenues have reduced the pressure on the government and private sector to increase competitiveness, but expropriation risk remains high. Negligible government debt reduces non-payment risk, but contract renegotiation and new obstacles complicate the business environment, which is weak even compared with some of its peers from former Soviet Republic (AON, 2013).

4.2.3. Political Risk

Besides low cost and gas availability, political risk is a key consideration to ensure profitable investments in energy based industries. As Russia, there are plenty of countries that are not so attractive for foreign investments due to their political risk. Based on the political risk graph published by Maplecroft in 2012, it will be identified which of the natural gas markets are truly industrial competitive. The graph is based on Maplecroft's Political Risk (Dynamic) Index which assesses risks that may experience sudden or rapid change due to direct government action or due to sub-state or other politically-motivated groups. It is comprised of five categories or risk indices: governance framework, political violence, business and microeconomics, forced regime change risk and resource nationalism.

Middle East countries in general, that have very cheap gas and big reserves, have a high political risk. Iran, which has the second world biggest natural gas reserve and low gas price, is placed by the Forbes World Riskiest Nations Article on number 6. It has high levels of political risk and a weak business environment, exacerbated by the effect of economic sanctions, which brought pressure on the exchange rate, facilitated corruption and reinforced high levels of government and military intervention in the economy. The government and connected leaders have been able to use the period of sanctions to consolidate power and undermine the role of private business. Political violence, supply-chain disruptions and political interference in the country are among the highest in the Middle East. Rule of law, accountability (and other freedoms) are weak and susceptibility to corruption is high (AON, 2013). Significant risk of political unrest is also present in Saudi Arabia, Kuwait, Egypt, Algeria, Uzbekistan, and Kazakhstan (Figure 61).

Figure 61: Political risk hotspots 2012



Source: (Maplecroft, 2012)

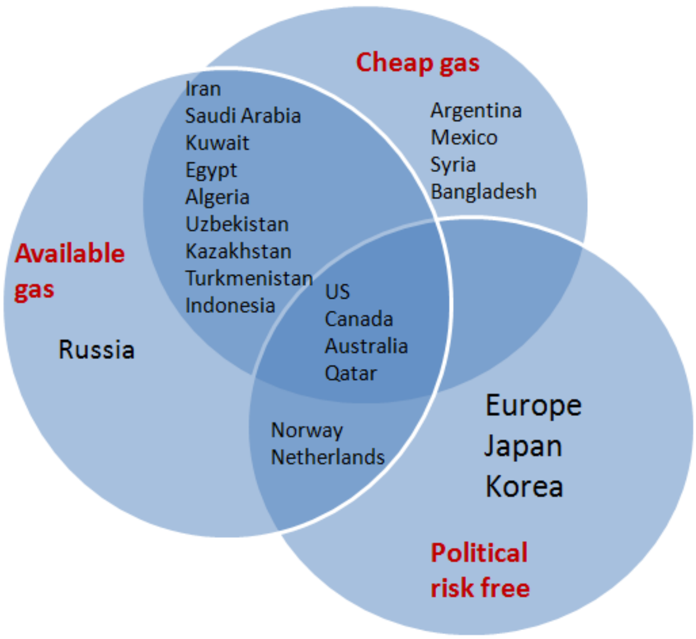
Venezuela also continues to have elevated risk indicators across the board, with particularly high exchange-transfer, legal and regulatory readings. High oil prices have strengthened the government's ability to meet its debt payments, although the fiscal accounts have significantly worsened in 2012 and willingness to pay remains an elevated risk (AON, 2013). The Forbes World Riskiest Nations Article place Venezuela on number 12 in the top.

Indonesia and Malaysia both have cheap gas and huge reserves, but are not political risk free countries. Indonesia, however, presents a much higher political risk than Malaysia, according to Maplecroft's study from 2013. In addition, there is a unique situation with these countries, especially Indonesia, as it consists of thousands of islands. Getting gas to population areas spread over these islands is hampered by a lack of transmission infrastructure. Therefore, transporting gas as LNG becomes a viable option for domestic consumption. As LNG installations already exists for their domestic need, is much convenient for these countries to export gas instead of receiving foreign investments.

4.2.4. The most industrial competitive markets

Adding the results from our analysis that comprises three criteria of a competitive gas market, the countries that have both available and cheap gas and is in a political risk free zone are: United States, Canada, Australia and Qatar.

Figure 62: Three criteria of a natural gas competitive market



Qatar is blessed with the third world gas reserves and the largest single concentration of non-associated gas in the world. It is a politically and socially stable country and production conditions favor the engagement in the vast power consuming industries. The country is located in the hub on the gulf region, and being a peninsula gives it longer shorelines and so more maritime access routes to the world, which makes it more competitive as a center for international investment. Also it helps it in being a major world producer and supplier of liquefied natural gas and other petroleum products. This status has considerably increased the country's income and helped further its social and economic structure development. However, its industrial competitiveness it's questioned by the position and the size of the country: it is surrounded by highly political risky countries. Moreover, Qatar is not a proper environment for foreign investments as it lacks in other resources necessary for an industry: it has a growing dependence of imported labor, water supply scarcity. Therefore, Qatar focuses its gas reserves on exports, especially to Asia and Europe.

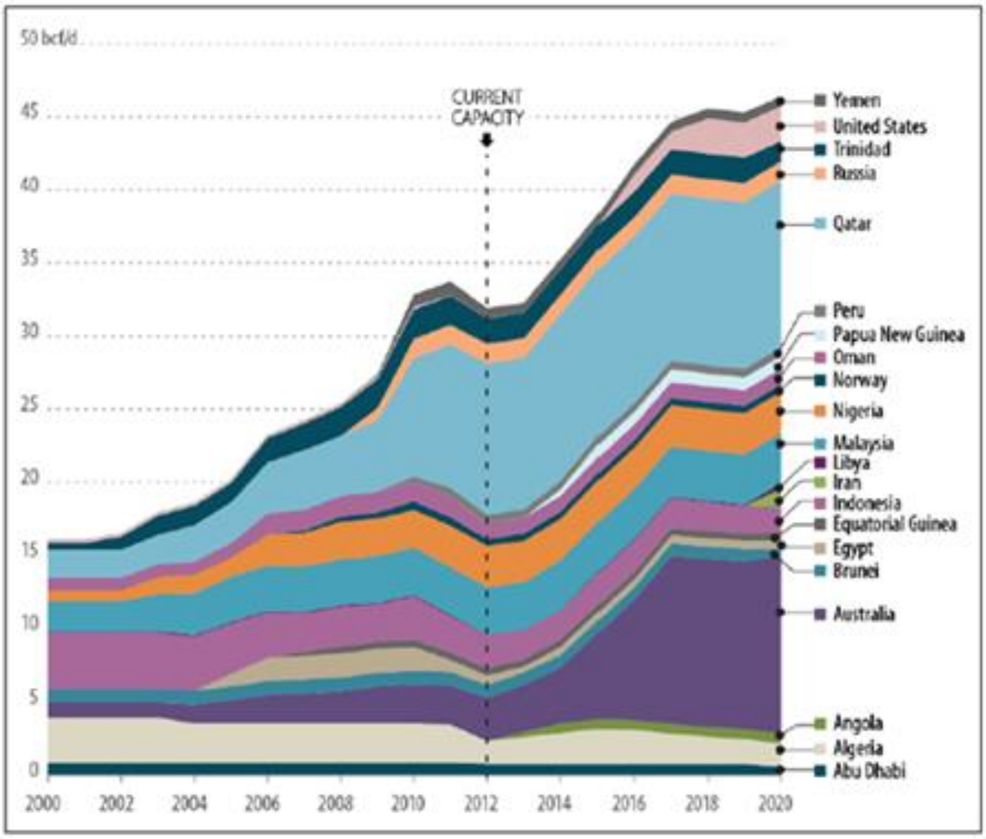


Figure 63[13]: Actual and Projected LNG Production Capacity 2000-2020

Another country that focuses its cheap and large gas reserves on exports is Australia. Australia is poised to overtake Qatar as the world's biggest exporter of LNG. Australia is not seen as an industrial competitive country by the petrochemical industries as, besides the gas, everything else is expensive, especially the workforce which is currently in decline due to ageing. "In the US, you are always going to have constraints with the need for gas in power generation and the chemicals industry. Australian LNG has its place," said Peter Coleman, the chief executive of Woodside, Australia's second-biggest producer of oil and gas (Neuhof, 2013). Australia’s attractiveness as a place to do business in a highly - globalized industry is slipping due to a combination of rising costs, declining productivity, increasing regulation and new taxes (Sheen, 2012).

[13]Source: (Ratner, Parfomak, Fergusson, & Luther, 2013)

Canada's cheap gas is highly related to US cheap gas, because the exports are pointed entirely towards US and are indexed to Henry Hub price. Therefore, Canada benefits of cheap gas as long as US has cheap gas, it has significant reserves of natural gas and is a political free risk country. However, there are other factors that weakness the Canadian competitiveness, broadly classified as population density and geography, jurisdictional fragmentation and regulatory burden, taxation and the cost of capital, and insufficient entrepreneurial ambition. Despite de fact that US market is also the closest trading partner, there are a multitude of internal barriers in Canada that constrain the mobility of goods, services and people, making a small market even smaller. Unnecessary regulations and procedures "slow down innovation, frustrate new product launches, operate to protect domestic producers from foreign competition and create a drag on competitiveness, productivity, investment and growth" (Competition Policy Review Panel, 2008).

Therefore, United States is the only country that, besides cheap, available gas and political free risk, it also has a market to provide to industries. Adding the high worker productivity, technological advance, supply chain and logistical advantages, developed network infrastructure and its thirst to recover after the economic crisis, US seems to be the most proper environment for gas based industries' investments. All these are complemented with a relatively low cost of capital and taxes.

Consequently, United States is becoming an increasingly attractive location for foreign businesses to operate. Of the total number of domestic and foreign chemical manufacturers companies that have announced investments in the U.S., roughly half are from overseas. The Japanese companies Idemitsu Kosan Co. and Mitsui & Co. have applied to build a chemical plant at a Dow Chemical Co. site in Texas. These Japanese companies are part of a growing trend, as more and more foreign chemical companies relocate to the U.S. seeking to benefit from secure supplies of inexpensive natural gas. Another recent example is the Chinese Company Sinochem, which inked a 1.7- billion dollar joint venture deal to acquire a stake in the Wolfcamp shale play in West Texas (Xin, 2013). Shell Chemical announced plans for an ethane cracking unit costing between $2 billion and $4 billion, to be constructed in Pennsylvania near Marcellus Shale natural gas supplies. Chevron announced plans for a $1 billion investment at its Baytown facility in Texas. In addition, Phillips Chemical, Westlake Chemical, and others announced investment plans related to low-cost shale gas availability. The impact in terms of competition threatens to be particularly strong in Europe, where high labor and energy costs are discouraging investment and driving companies elsewhere**.** Since 2009, the

German-based chemical giant BASF "has channeled more than $5.7 billion into new investments in North America, including a formic acid plant under construction in Louisiana"(American Chemistry, 2013). Brazilian petrochemical companies like Braskem, Gerdau, Votorantim and Vale have also showed interest in the American shale gas[14].

4.2. The reindustrialization of the US market

4.2.1. Incentives to invest in US industry

Natural gas is now at the heart of the debate about the present and future of energy in the US. The reasons behind this growing interest in natural gas find their roots is the shale gas discoveries that changed the US position on the gas market in the world. Firstly, US authorities have regarded natural gas as a mean of reducing the dependence on other fossil fuels, being considered a promising candidate for meeting future demand under carbon dioxide emission constrains. Besides the contribution brought in power sector, low cost gas provides US an enormous potential benefit in the industrial sector.

As concluded in the previous section of this chapter, the most industrial competitive market nowadays is the US gas market. The important energy advantage is given by the exploitation of shale gas that has led to a dramatic reduction in gas prices, from highs of around $12/MMBtu in 2008 to a low of 1.80/MMBtu in March 2012. Since then, the price has recovered, reaching $3.68/MMBtuin October 2013. These very low natural gas prices have resulted in a windfall benefit to US consumers, accelerated a large-scale shift in power generation away from coal, challenged the hypothesis of convergence between gas and oil prices and helped re-energize the US's industrial economy. Given the big price difference with other markets ($8/MMBtu in Europe, $10/MMBtu in China, $14/MMBtu in Brazil and $17/MMbtu in Japan), many gas intensive industries (such as petrochemical companies) are trying to find different ways of benefiting on the cheap gas, by moving plants or investing in US.

However, cheap natural gas will probably not have any broader impact beyond a few industries, as energy is still a small fraction of costs for most industries. Therefore, the objective of this section will be limited at the energy intensive industries. The petrochemical business is unique among manufacturers as being the only one which relies upon energy inputs, not only as fuel and power for its operations but also as raw materials in the manufacture of many products.

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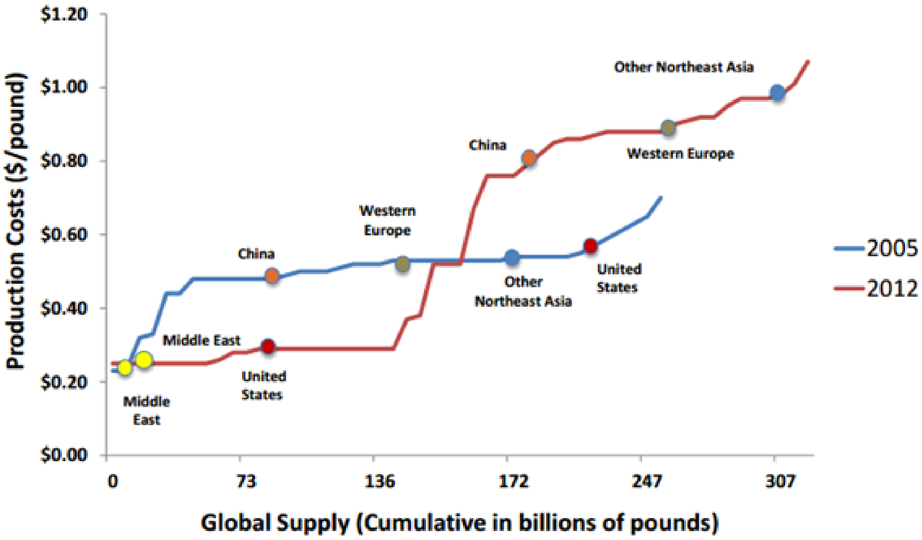
[14] See Annex A for the list of the companies that have announced shale-related chemical industry investments in US

The revolution in shale gas has pushed ethane prices down from a peak of 93 cents per gallon in 2008 to an average of 41 cents per gallon during 2012, reaching a decline of 51%. In early months of 2013, the price fell to as low as 23 cents per gallon. Therefore, US is now one of the low cost producing nations for ethylene, as the Figure 64 illustrates. Ethane is difficult to transport, so most probably, the additional ethane supply will be consumed domestically by the petrochemical sector to produce ethylene.

Figure 64: Change in the global cost curve for ethylene and renewed US competitiveness



Source: (American Chemistry Council, May 2013)

U.S. chemical companies are heavy users of ethane, whereas European and other foreign chemical companies use naphtha, a more expensive feedstock derived from oil, to manufacture similar products. Because of relatively high oil prices, it costs naphtha-based plants up to $1,200 a ton to produce ethylene. In sharp contrast, ethane-based plants can produce ethylene for roughly half that amount. This wide price disparity between ethane and naphtha has provided U.S. chemical firms with a massive cost advantage and plenty of incentive to relocate back to the United States. For instance, Dow Chemical is planning to construct a new ethylene unit along the U.S. Gulf Coast by 2017, reopen an idled ethylene plant in Louisiana this year, and build a new propylene facility in Texas by 2015. The company hopes to benefit from cheap feedstock sourced from the Marcellus and Eagle Ford shale. Similarly, Shell is constructing a petrochemical refinery in the Appalachian region, also aiming to capitalize on cheap feedstock from the Marcellus shale. Shell Chemicals recently announced plans to build an ethane cracker in Pennsylvania (Sreekumar, 2012).

4.2.2. Investments and Foreign Direct Investments in US

For some energy intensive products, energy for both fuel for power needs and feedstock account can represent 85% of total production costs. Thesekind of industries is where cheap shale gas is making a difference in the US. Eight key industries are expected to spend an estimated total of $72 billion in private investment over several years on new plant and equipment in US: paper, chemicals, plastic & rubber products, glass, iron & steel, aluminum, foundries and fabricated metal products (American Chemistry Council, May 2012).

Therefore, it has been arrived to the question of a reindustrialization process in US. Of course, the process of deindustrialization and reindustrialization in US is much larger than energy can explain, but without any doubt, energy is one important factor and today natural gas is finding its place at the heart of energy discussion.

In the beginning of 2000, world oil prices were dramatically high and US natural gas prices have reached higher levels than most of other markets. Consequently, back in the mid-2000s, when natural gas and NGL prices spiked, many domestic chemical firms lost competitiveness and were forced to idle their plants and invest in other countries. In 2005, for example, of the 120 largest chemical plants built around the world, only one was located in the US (Halpern &Lopp, 2007). In iron and steel industry, US has invested in 2002 in iron making operations in Trinidad and Tobago and Brazil, to take advantage of the cheap gas there at that moment.

Therefore, in the past decade United States witnessed a large deindustrialization, being seduced by China's subsidies, lax regulation, cheap labor and raw materials. Since 2001, US has lost approximately 42.400 factories and together with it, tens of millions of jobs, 32% in the manufactory. In 1959, manufacturing represented 28% of US economic output and in 2008, it represented only 11.5%.

However, lately the US industry is taking a new turn: the Master Lock recently returned to its original home base in Milwaukee, Michelin is breaking ground on a new tire plant in South Carolina, Volkswagen has new facilities in Chatanooga, Tenn., Airbus is building a $600 million plant in Mobile, Alabama, Samsung plans to invest more than $20 billion in various US manufacturing enterprises and GE moves manufacturing divisions back home from China. The back-to-America trend is called "reshoring" — and it's fast replacing outsourcing. One reason for reshoring is the rising transportation costs of moving finished goods from overseas, making outsourcing more costly. Another reason is quality control, as US workers using new computerized tools and processes get better results than India's or China's low-cost-but-low-skilled assembly lines. Moreover, Chinese labor cost is in a constant increasing, rising 13.6% last year. Not negligible is the risk of doing business in a country like China, a dictatorship with a still-uncertain future. By contrast, producing in USA comes with the rule of law and an environment that still fosters free-market competition, including for labor. Besides the shrinking wage gap between China and the United States, the productivity of the American worker keeps rising. Adding to all this an affordable cost of capital and taxation, US is nowadays one of the most competitive markets (The Economist, 2013).

Willing to take advantage of this industrial competitiveness in the petrochemical sector in US, nearly 100 major projects have been announced, some of this representing foreign direct investment from chemical companies in Brazil, Canada, Germany, Indonesia, Saudi Arabia, South Africa, Taiwan and elsewhere. The estimated cumulative capital investment totals $71.7 billion through 2020. The American Chemistry Council Report, *Shale Gas and New Petrochemical Investments: Benefits for the Economy, Jobs and US Manufacturing*, discusses the impact of a hypothetical but realistic 25 percent increase in the ethane supply on growth in the US petrochemicals. The report conclude that the increase would generate new capital investment and production in the chemical industry, job growth both in the chemical industry and in its supplier sectors, expanded output throughout the US economy and increases in federal, state and local tax revenue. It is noticeable the sense of irony: just over five years ago, natural gas was a major impediment to the U.S. chemical industry; now, it's a lifesaver (Sreekumar, 2012).

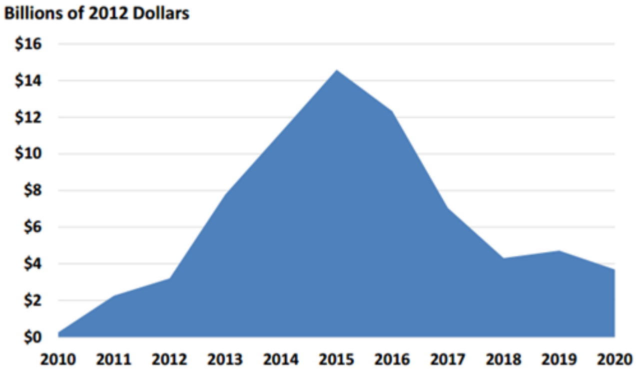
Year	2010-12	2013	2014	2015	2016	2017	2018	2019	2020	Total
Investment (billions of dollars)	$5.7	$7.8	$11.3	$14.6	$12.4	$7.1	$4.4	$4.7	$3.7	$71.7

Table 7[15]: Incremental US Chemical Industry Capital Expenditures arising from Shale Gas-Induced Renewed Competitiveness

Chemical industry investments related to shale gas actually began in 2010. Between 2010 and 2011, a total of $5.7 billion of shale-related capital expenditures has already been spent. The scheduled start-up dates of announced projects indicate that capital spending will peak at $14.6 billion in 2015.

[15]Source: (American Chemistry Council, May 2013)

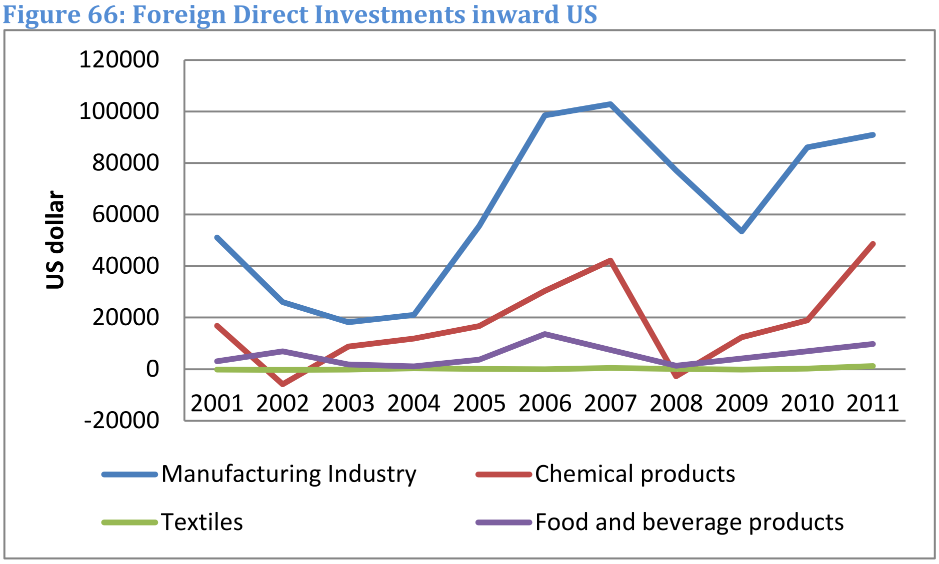
Figure 65: Incremental shale-related US chemical industry capital expenditures



Source: (American Chemistry Council, May 2013)

Foreign direct investment in US indicates as well the increased competitiveness of the market. In the manufacturing industry, especially in the chemical sector, the level of investments increased substantially, like the graph below shows. A big contribution is given by the shale gas, proof being the fact that in less gas intensive sectors (food products and textiles), foreign direct investments are not as strong in the lasts years.

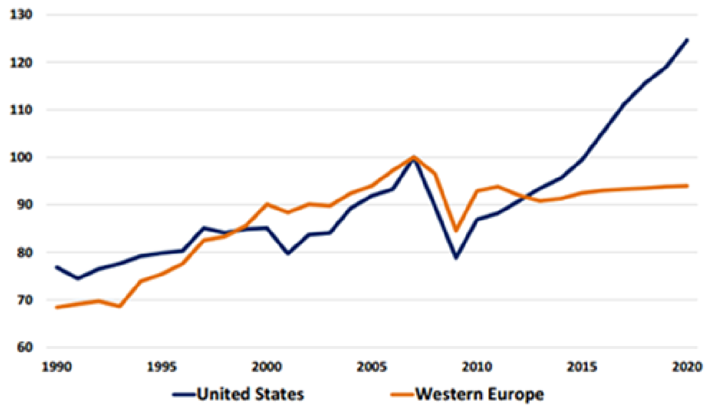
Figure 66: Foreign Direct Investments inward US



Data Source: IEA Database

Therefore, all these investments have a visible effect upon the volume index of production in US chemical industry. Compared to the chemical industry evolution in Western Europe, the effect of the competitive advantage in US is significant. It is important to mention that the strong increase in supply doesn't cover only the domestic demand, but the export opportunities are to be exploited.

Figure 67: US Chemical industry growth compared with growth in Western Europe



Source: Eurostat, Federal Reserve, ACC analysis

4.2.2.1. Companies that have announced shale-related chemical industry investments

In 2008, none of the members of the American Chemistry Council (ACC) foresaw investing any more in the country. Now, in the wake of the shale gas boom, the ACC lists 110 new investment projects for the US, worth some $77 billion. If all come to fruition, the ACC sees 46,000 new direct jobs, plus another 200,000 for subcontractors, in a sector that employs 800,000, compared with 1.1 million in 1981.

Press, hundreds of news and chemical companies investment plans announce that shale gas is powering US petrochemical revival. There is clearly much effervescence in this industry lately. While Europe and China are complaining for loosing competitiveness and are starting different projects for shale gas exploration, US industry is in blossom. Natural gas is sold in US for one third the price in Europe and one fifth in Asia and this makes it even more a boom for the petrochemical industry. Existing plants are working at full capacity; plants that were shut down are being started back up again; and others are boosting capacity, industry officials say. "So everybody's saying: hurry up to build something, because at that natural gas price, it's just pure value", a petrochemical analyst at IHS, said in Texas, the capital of the US industry. Therefore, there is a lot of ethylene cracking capacity to be built or expanded in the next 5 years in US.

Company	Type	Capacity (MM mt/y)	Completion
Aither Chemicals	Newbuild	0.20 – 0.30	2016
Appalachian Resins	Newbuild	0.25	
BASF- Total	Expansion	0.06	2012
BASF- Total	Expansion	0.1	2014
ChevronPhillips Chemical	Newbuild	1.5	2017
Dow Chemical	Restart	0.4	2012
Dow Chemical	Expansion	0.4	2014 – 2016
Dow Chemical	Newbuild	1.5	2017

ExxonMobil Chemical	Newbuild	1.5	2016
Formosa Plastics CUSA	Newbuild	0.8	2016
Ineos	Expansion	0.12	2013
LyondellBasell	Expansion	0.83	2014 – 2016
Occidental/Mexichem	Newbuild	0.55	2017
Sasol	Newbuild	1.5	2017
Shell Chemical	Newbuild	1 – 1.5	2017
Westlake Chemical	Expansion	0.11	2013
Westlake Chemical	Expansion	0.08	2014
Westlake Chemical	Expansion	0.11	2015
Williams	Expansion	0.23	2013

Table 8: New US Ethylene Cracking Capacity 2012-2017

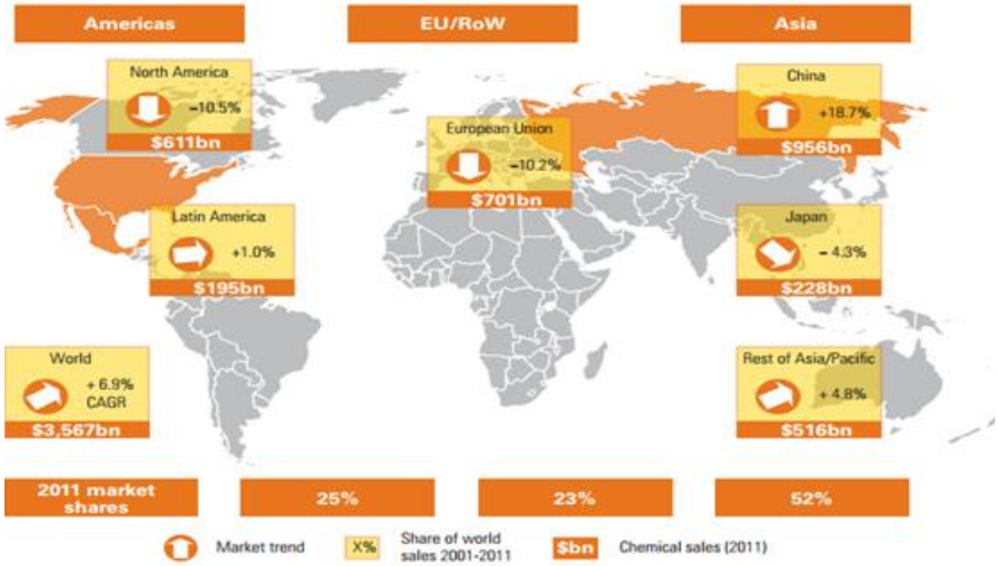
4.3. Industry's dynamics function of gas price

Competitiveness is regarded as the main condition for existence in the new global market. Success of a country in the process of competition is closely related to the degree at which it can simultaneously increase the real incomes of its citizens and produce internationally demanded goods and services in accordance with free and fair market. In addition, a country's or a region's competitiveness includes the provision of high living standards and employment opportunities. Manufacturing industries is regarded as one of the most important economic activities that enable sustainable competitiveness and economic growth (Kumral, Deger, &Turkcan, 2008).

The competitive advantage offered by the shale gas boom has already created, and will continue to create, winners and losers. If natural gas prices remain depressed, some of the biggest winners should be American chemical manufacturers. As analyzed in the third chapter, the achievement of a global gas price in the next 15 years is unlikely to happen. Industrial competitiveness is driven, along with the above mentioned factors, by the specific gas prices and pricing mechanisms and policies, as observed today.

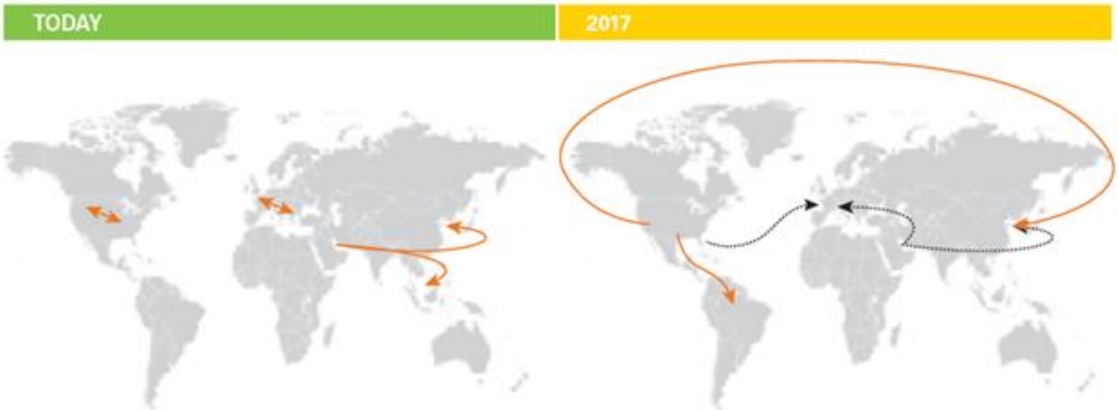
The impact of US shale gas in the chemical industry seems to be huge, providing competitively priced energy. "Made in America" is becoming a cost competitive option once again, leading some multinationals to re-base their production activities in the US. Therefore, a shift of supply from main emerging markets will take place. As figure 68 shows, countries in Latin America, Asia – Pacific (except Japan) and China have registered in the last decade increased chemicals sales. On the other hand, North American market, Europe and Japan have decreased chemicals sales in the last decade. The emergence of shale gas in United States will shift the large part of chemicals supply to US, changing thus the global trade flows, as Figure 69 shows.

Figure 68: World Chemicals Sales by Region



Source: (KPMG, 2013)

Figure 69: Changing Chemicals trade flow because of Shale Gas



Source: (KPMG, 2013)

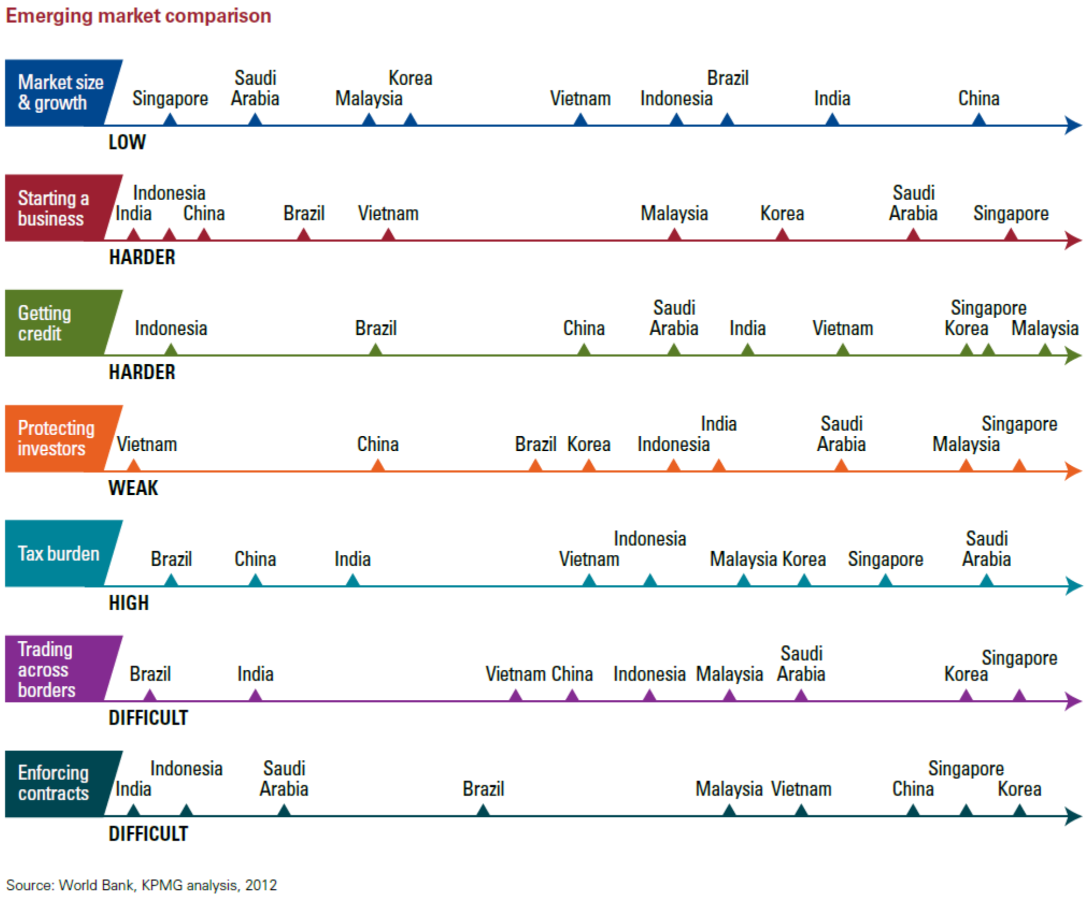
The opening and the construction of new chemical plants in the US will result in great supply that will exceed the local demand, orienting US Petrochemical industry towards exports. Most probably, exports will take place to the emerging countries in Latin America as well as to Asia Pacific emerging markets. Currently, Asian market is predominantly served by local product supplemented by vast imports from Middle East. As US product starts to flow to Asian markets, we may see increased price competition.

On the other hand, large parts of European commodity chemical industry are characterized by over-capacity and older, less efficient plants. Whether US producers will export directly to Europe, or will let Middle East producers to respond to increased competition in Asia by redirecting their export focus to Europe, is to be seen.

However, gas price is not the only driver for the industrial competitiveness and the industry's dynamic. Other factors that are able to influence the industrial competitiveness are the political regime, country's local policies and taxes, available infrastructure, workforce and technology, market size and growth and closeness of the consuming market, easiness of trading across borders, policies regarding starting a business, easiness of getting credit, protecting investors etc. In case of eventually achieving a global gas price, these will become the primary drivers.

Figure below ranks the emerging markets function for different factors that influence the industrial competitiveness of a country. According to how much a country presents competitive advantages, companies in the industries will decide whether to move close to the developing market or might decide to produce in a better business environment and export towards these markets.

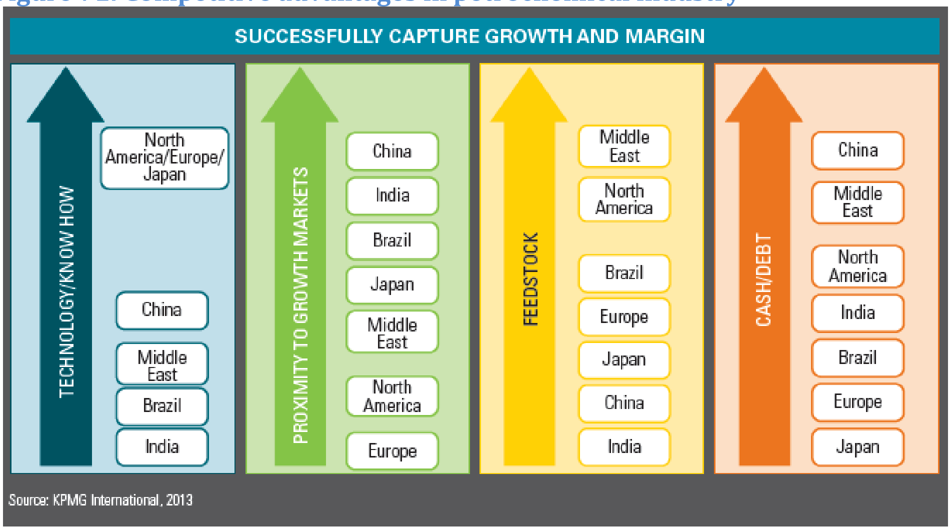
Figure 70: Factors that promote industrial competitiveness



Source: (KPMG, 2013)

From the technology point of view, North America, Europe and Japan are still way ahead of other markets, providing thus an important advantage for the petrochemical industry. In terms of feedstock price and availability, Middle East and North America are in top, but this is strongly dependent on how gas prices evolve and how other markets will start exploiting their gas reserves (especially China the shale gas reserves and Brazil its pre-salt reserves).

Figure 71: Competitive advantages in petrochemical industry



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Source: (KPMG, 2013)

In a context of global gas prices, petrochemical industries won't have strong incentives to migrate between the markets. Therefore, massive movements won't be probably seen, but singular decisions of changing location or investing in new location will be driven by the other competitive advantages. Unlike national companies, multinational companies will especially have a grown interest in gaining competitiveness on the market. National companies will most likely not be willing to give up governmental support and national benefits.

Conclusion

Gas price, gas availability and the degree of political risk are three important factors that can strongly influence the industrial competitiveness of a country from the perspective of the gas intensive industries. The analysis based on these criteria conducts to the result that few markets are predisposed to this competitive advantage: US, Canada, Qatar and Australia. However, only US represents a real attraction for gas based industries, as the other ones have their competitiveness limited by some unfavorable factors as labor and other raw materials cost and availability, taxes, regulatory burden or insufficient entrepreneurial ambition.

The conclusion of the analysis is highly supported by the dynamics of the industry today, as US seems to witness a reindustrialization: "The US petrochemical industry, in trouble just a few years ago, is making a spectacular comeback thanks to the boom in shale gas, shaking up the industry worldwide and spreading some discomfort through Asia and Europe", as Marc Preel from AFP, a French press agency announced (Jun 11, 2013).Now US is in a renaissance. Chemicals are at the forefront, but there's a rebirth of manufacturing there. A spectacular number of new project are announced and new of ethylene cracking capacity is to be built or expanded in the next 5 years in US.

Therefore, industry's dynamics will be strong influenced by the US' shale gas as long as prices will be lower here. Other factors that create competitive advantages, as political regime, country's local policies and taxes, available infrastructure, workforce and technology, market size and growth and closeness of the consuming market, easiness of trading across borders, will gain greater importance in the context of a uniform gas price.

Fifth Chapter: The actual impact of the natural gas price on the industry's growth – a data analysis for the case of United States and Brazil

> ***"Brazil cannot compete against an industry that sells gas for $3.5 to $4 per MMBtu if it charges $12 to $15 per MMBtu... However, the country (...) is positioned amongst the top five largest global economies and chemical industries worldwide" (IHS, 2012)***

Introduction

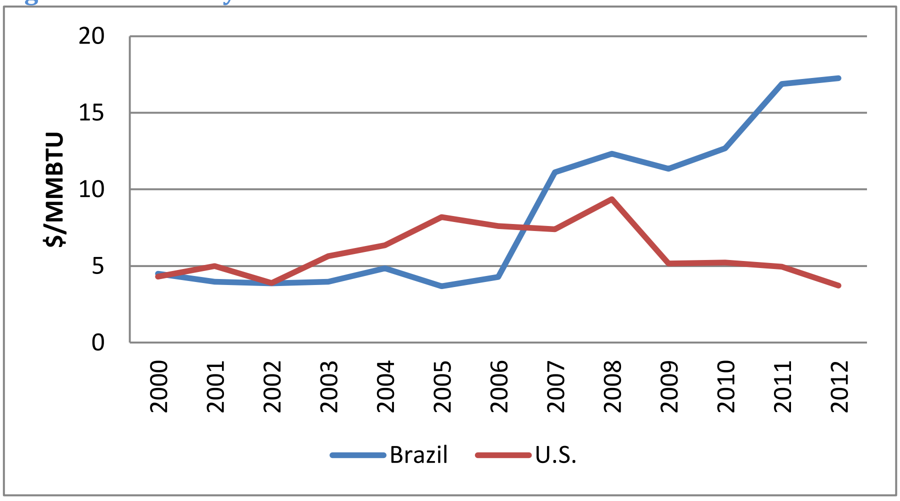
Natural gas is a vital component of the world's supply of energy. It is one of the cleanest, safest, and most useful of all energy sources. The industrial sector uses more energy than any other end-use sector, consuming about one-half of the world's total delivered energy. Being an important element in the cost structure of some industry's sectors, one could assume that natural gas price changes have a quite strong impact on the industry's dynamics. This chapter is aimed to assess the impact of natural gas prices in two contrary cases: a natural gas market that presents a high level of industrial competitiveness by its low prices, and on the other hand an underdeveloped natural gas market that presents high gas prices.

As the previous chapter shows, the competitive advantage in US industry is a much discussed topic nowadays. The abundance of supply and low costs due to shale gas seem to be able to reshape at least some of the industries. This chapter aims to add evidence on this by taking a closer look on the impact that natural gas actually has on the economic growth. In this sense, a data analysis will be preceded on the evolution of a few indicators: GDP by industrial sectors, energy mix, the energy mix evolution, energy and gas intensity of the most representative industries and the gross output of these industries in US.

Natural gas price is clearly not the only factor that drives the industrial growth and competitiveness of a country. Therefore, another case study will address the question of how successful are the energy intensive industries in the markets where natural gas is lacking competitiveness. However, as previous chapter shows, Brazil presents the big advantage of having a huge domestic market and large feedstock reserves to be exploited in the pre-salt area. In this scope, Brazil's case will be analyzed through the perspective of the same indicators: GDP by industrial sectors, energy mix, energy and gas intensity of the most representative industries.

The analysis considers first the US case, where since 2009 gas prices dropped, and secondly, the Brazil case, which should present a different evolution of the industry indicators as the gas prices are maintaining themselves at increasingly high levels since 2007. It will be considered the time period of the last decade, from 2000 to 2011-2012, according to data availability.

Figure 72: Industry Gas Price in US and Brazil



Data Source: BEN, EIA

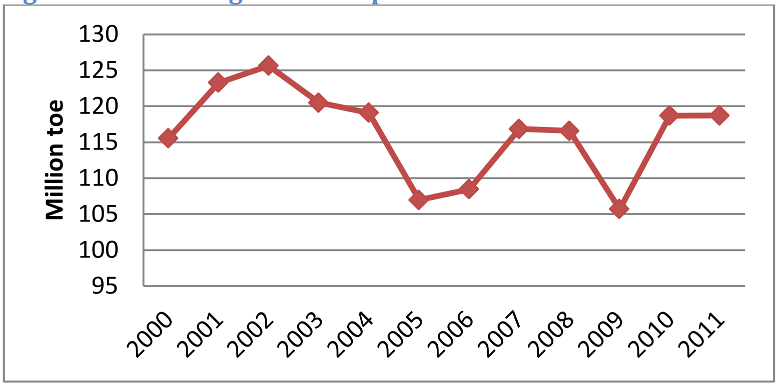
The figure above illustrates the evolution of the gas prices in the industry in both cases: US and Brazil, from 2000 to 2012. In US, gas prices followed an ascendant trend until 2009, when excessive shale gas supply dropped industrial prices from 9.36 $/MMBtu to 5.15 $/MMBtu. Since then, prices continued decreasing, reaching 3.69 $/MMBtu in 2013. On the contrary, gas prices in industry in Brazil continue increasing since 2007, reaching in 2012 its maximum of 17.25 $/MMBtu.

5.1. Case Study I: The impact of the competitiveness advantage upon the industry's dynamics in United States

5.1.1. Gas Consumption in Industrial Sector

In the US industry, natural gas is a very important source of energy. Natural gas consumption in the industry sector was around 120 million toe in 2011, meaning a share of 40% in the industrial energy mix. In rapport to price evolution, natural gas demand seems to be quite elastic: over the period 2002-2005 prices increase around 4$/MMBtu, while consumption decreases almost 20 million toe; over the next 2 years, 2005-2007, prices drop and consumption increase. However, when prices drop with 4.2$/MMBtu from 2008 to 2009, consumption drops more than 10 million toe. Nevertheless, while the gas prices continue to be low, demand increases in 2010 and 2011 at 118 Million toe.

Figure 73: Natural gas consumption in the Industrial sector in US

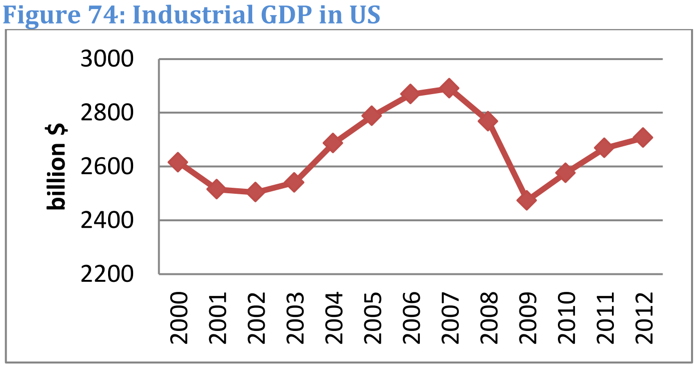


Data Source: IEA Energy Balance for OECD Countries

5.1.2. Industrial GDP

The drop in the industrial gas consumption in 2009 is due to the strong economic crises that occurred worldwide, while the increase in 2010 is more related to the crisis recovery than to the evolution of prices. This is also proven by the drop in the industrial GDP in 2009. Industrial GDP in US decreased from 2007 to 2009 with 14,4%. However, in the last 3 years it is strongly increasing, in 2012 being 9.4% higher than in 2009.

Figure 74: Industrial GDP in US



Data Source: IEA database

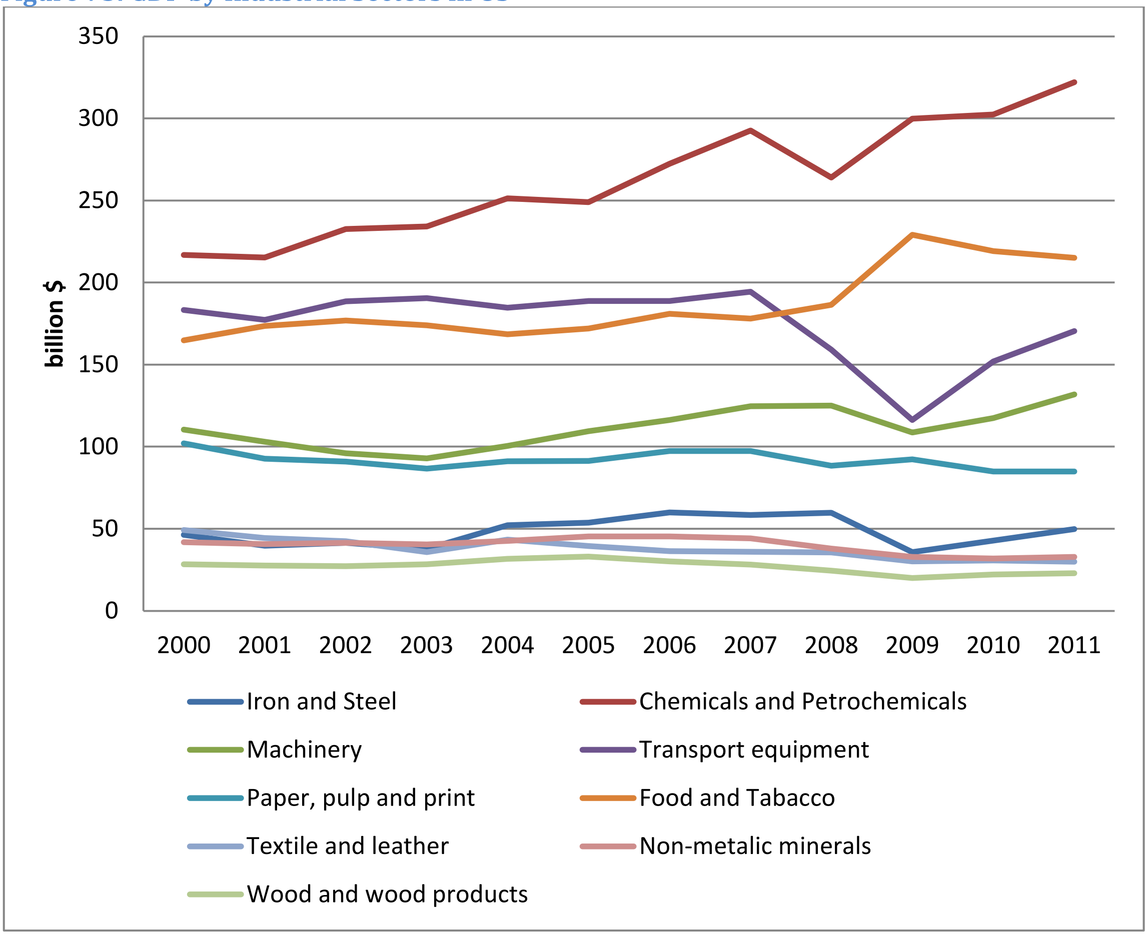
The period we focus the analyze on (since 2009) coincides with the economy's recovery after the crisis. Therefore it is more difficult to assess if the ascendant trend in the lasts years is influenced at some extent by the low gas prices. For that, it will be analyzed the evolution of gas consumption and GDP in the energy intensive sectors, in comparison to the less energy intensive sectors of the industry.

As GDP is considered the broadest indicator of economic output and growth, it is interesting to observe how GDP in different sectors of the industry evolved over the lasts years in US. The graph below illustrates the evolution of the GDP of some sectors of the industry from 2000 to 2011. The effect of the economic crisis in 2008-2009 is observable, as the GDP in most of the sectors dropped considerably: chemicals and petrochemicals, transport equipment, machinery, non-metallic minerals, textile and leather, wood and wood products industry. However, starting with 2009, the GDP in most of the sectors increases, due to the recovery after crisis. Whether low gas prices contributed to the crisis recovery is the next question to answer. It is compared therefore the energy intensive sectors with the less energy intensive sectors of the industry.

- Energy intensive sectors: chemicals and petrochemicals, iron and steel, non-metallic minerals (aluminum, cement, lime, glass), food and tobacco, paper, pulp and print
- Non Energy intensive sectors: Machinery, Transport equipment, textile and leather, wood and wood products.

It is observable that in the energy intensive industries the GDP increase in the last years is slightly faster than in the less energy intensive industries, an exceptional increase being witness by the chemicals industry.

Figure 75: GDP by Industrial Sectors in US



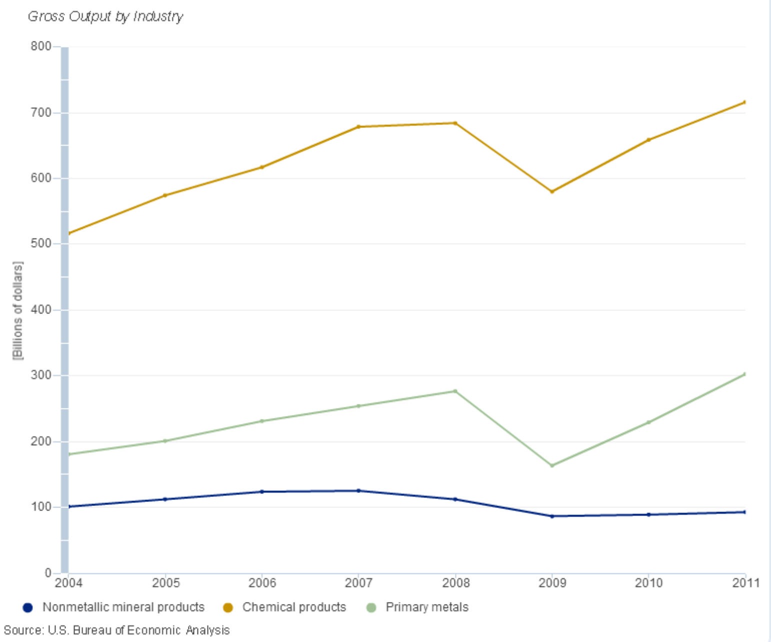
Data Source: Bureau of Economic Analysis

Chemicals and petrochemicals industry has an important contribution in the US economy, being responsible for about 12% of the U.S. industrial production measured as value added. It consumes approximately 25% of total industrial energy consumption in the U.S. (2011). The strong increase in the lasts 2 years coincides with the recovery after the economic crisis, but as it exceeds pre-level crisis, it means it doesn't feed just the local demand, but export opportunity arose. These opportunities might have been given by the cheap shale gas and the idle plant capacities. As the U.S. chemical industry has two primary uses for natural gas -- as a raw material, or "feedstock," and as a way to power its facilities, cheap gas is becoming increasingly attractive for both purposes.

5.1.3. Gross Output of Energy Intensive Industries

Gross output of chemical products industry and primary metals (iron and steel industry) is strongly increasing in the lasts years, exceeding the pre level crisis. The output of these industries is allowed to increase by the export possibilities, not being constrained by the domestic demand increase. It is, however, constrained by the production capacity.

Figure 76: Gross Output of Energy Intensive Industries in US



Source: U.S. Bureau of Economic Analysis

For local services, competitiveness is interpreted also as the capacity to generate growth, but only from the creation or expansion of the domestic market. For tradable goods and services, competitiveness translates in the attractiveness of a location for new investments and the capacity of local operations to compete regionally or globally, generating growth in the sector overall. Chemicals products are tradable goods, and the sector's competitiveness in proven by the increased exports along with the increase in the gross output of the sector.

Figure 77: Chemicals Exports and Trade Surplus in US

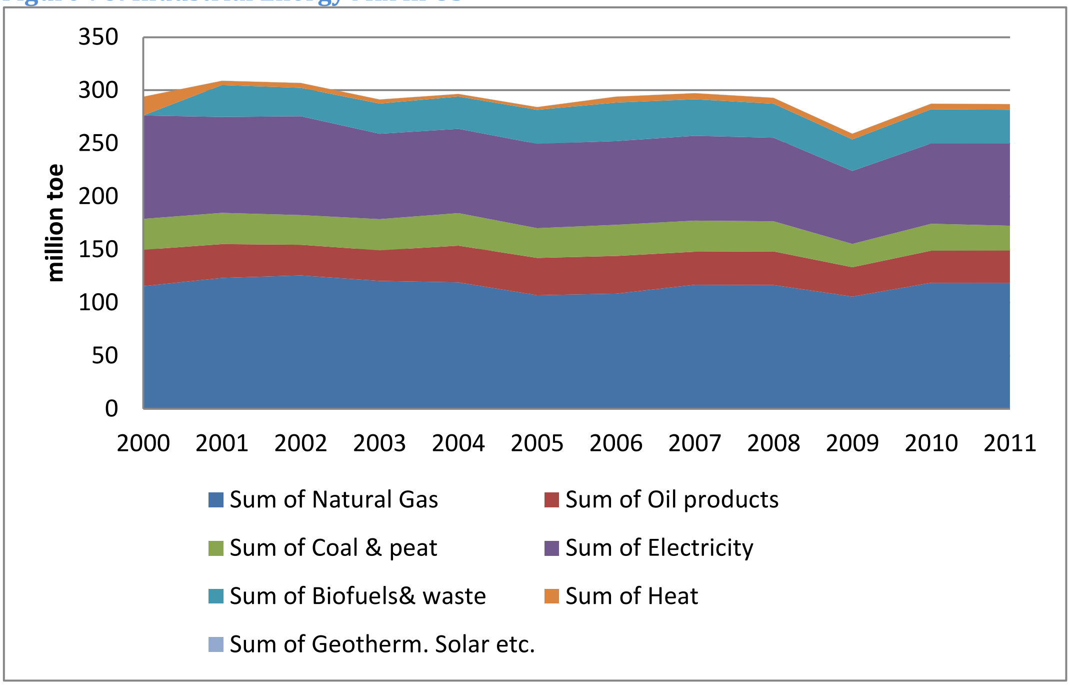
Source: (American Chemistry Council, 2012)

Specialist argue that these highly competitive global industries, operating at large volumes with relatively low margins, both capital and energy intensive, can present production levels highly elastic with respect to natural gas price in the short term. Over the longer term, changes in demand will be dependent upon allocation of capital investment in new plant capacity (MIT, 2011).

5.1.4. Energy Mix

Next step of the analysis is to take a look at the evolution of the contribution of natural gas in the energy mix in the industry in US and to identify any correlation between the increase in GDP over the lasts years and natural gas consumption. The figure below illustrates that natural gas contribution is maintained relatively constant over the last 11 years, at around 40% of the total energy consumption in the industry.

Figure 78: Industrial Energy Mix in US

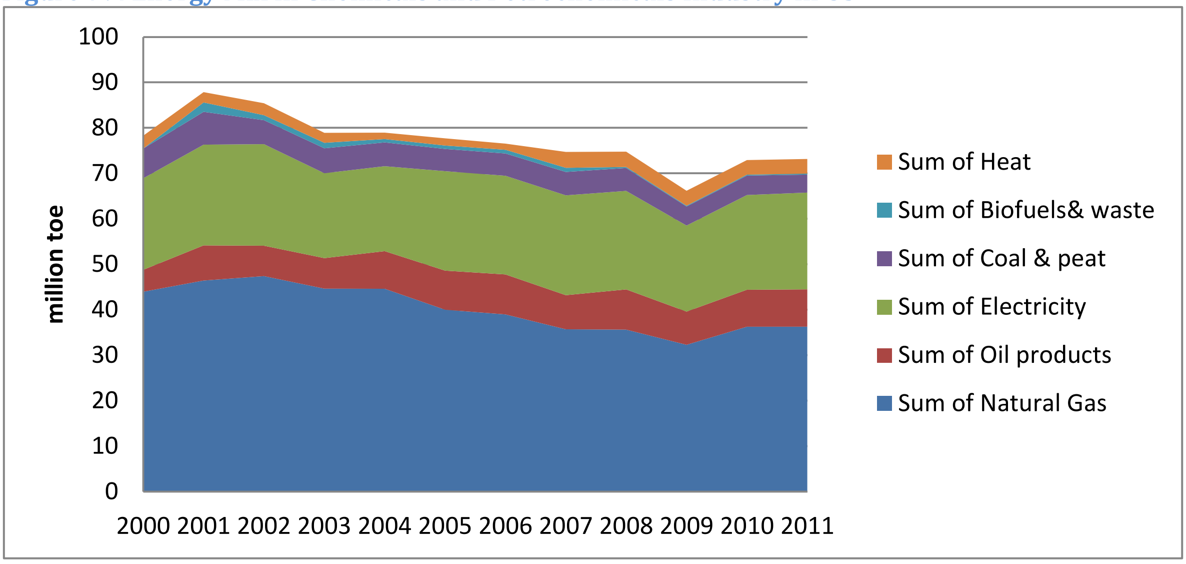


Data Source: IEA Energy Balance for OECD Countries

Evolution of natural gas contribution in the industrial sector in general might be a too broad analysis. Therefore, we take a look on the energy mix in different sectors in order to observe whether or not natural gas consumption increased, given the extra supply of shale gas and the low price.

The most significant ones are the energy intensive industries, as for them the lower gas price can make a difference in the cost structure. **Chemical and petrochemical industry** is one of the most energy intensive industries, for which natural gas represents around 50% of the energy source. Back in 2005, when gas prices increased from 6.35$/MMBtu to 8.19$/MMBtu from one year to another, gas contribution in the energy mix decreased by 5%. This cost disadvantage decreased domestic's firm competitiveness, leading several U.S. chemical manufacturers to idle their plants. But after several years of coping with high and volatile natural gas prices, current low prices have provided them with a significant competitive advantage over their foreign counterparts. Therefore, the last 3 years of low gas prices increased its' contribution by 2%.

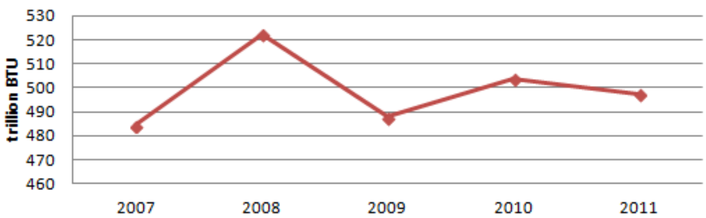
Figure 79: Energy Mix in Chemicals and Petrochemicals Industry in US



Data Source: IEA Energy Balance for OECD Countries

Natural gas consumption used as feedstock in the industry has recovered after the crisis in 2009 but significant reaction at the price decrease is not visible until 2011.

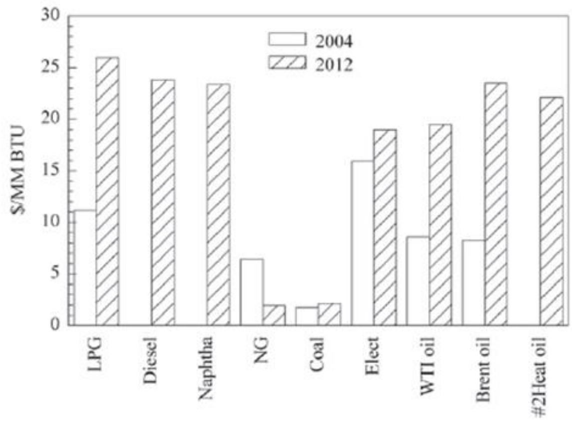
Figure 80: Natural Gas Consumption used as feedstock in Chemical Industry



Data Source: EIA Annual Energy Outlook

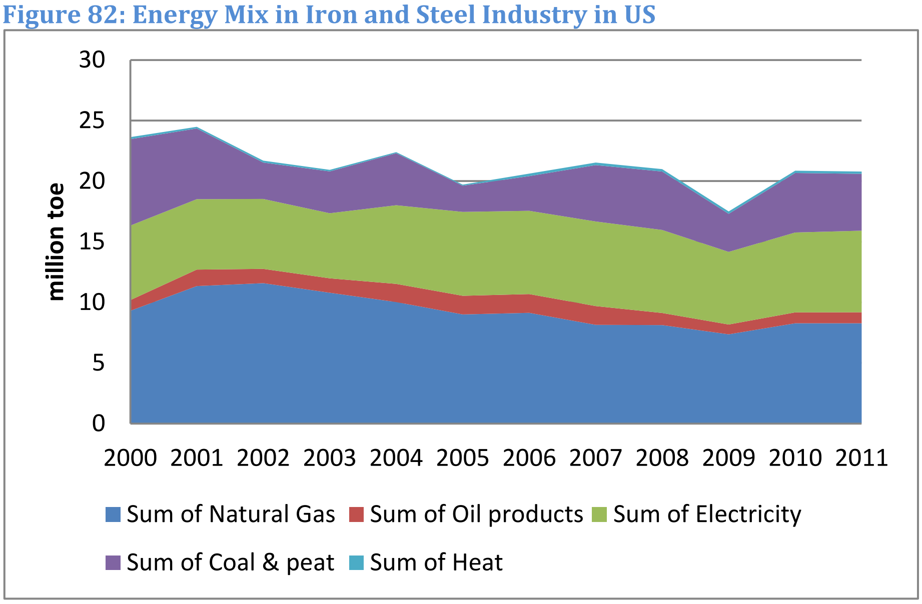
Natural gas consumption used as feedstock in chemical industry didn't increase as much as one could expect, despite the significant decrease of the prices (Figure 80) and all the new announced investments. One reason might be that the construction of new capacity takes few years and the completion of most of the new or extended plants is foreseen from 2014 on. Therefore, considerable consumption increase cannot be seen until 2011. However, the consumption can reach the levels from year 2008, by putting in function the idle capacity. "We have not estimated changes in US natural gas demand associated with potential changes in global market competitiveness of these commodities (feedstock)" (MIT, 2011). Ironically, demand did not immediately respond to these lower prices.

Figure 81: Comparison of US feedstock costs in USD $/MMBTUs 2004 vs. 2012



Iron and steel is another energy intensive industry. Since 2002 until 2009, natural gas lost around 15% of its share in the energy mix, from more than a half – 53.4% to 38%. In 2009, a slightly increase took place, gas gaining 4% more to its share, and maintaining relatively constant in the following two years.

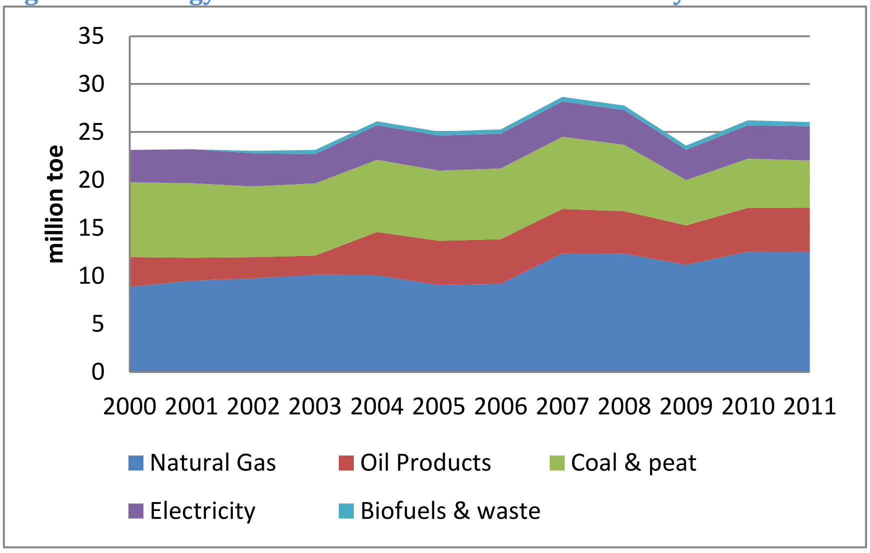
Figure 82: Energy Mix in Iron and Steel Industry in US



Data Source: IEA Energy Balance for OECD Countries

Non-metallic mineral industries include energy intensive industries as cement, ceramics, clay and glass. Natural gas accounts for around 40% of total energy mix. Natural gas lost 6% share over the years 2004-2006, but since 2007 it started to recover and increased 12% in its share. Since then, the natural gas consumption in this industry is rather constant, with a drop during the economic crisis period.

Figure 83: Energy Mix in Non-metallic Minerals Industry in US



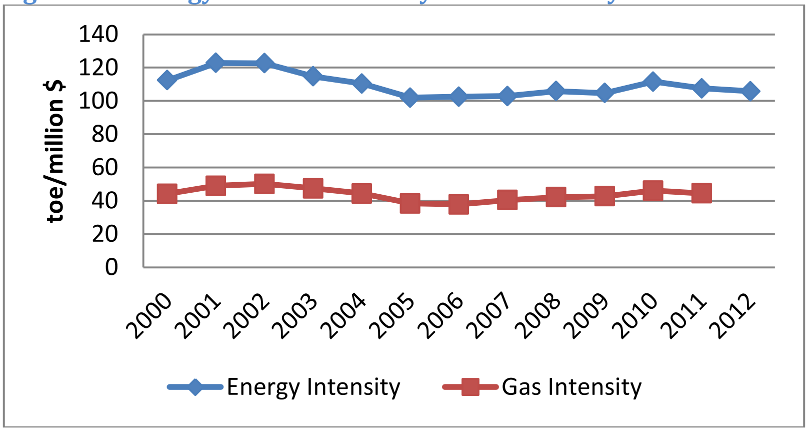
Data Source: IEA Energy Balance for OECD Countries

It is not observable a significant change in the energy mix structure of any sector of the industry over the last 3 years, in respect with the extra shale gas supply and very low prices. However, an increase of few percent occurs in the share of natural gas over the last years in the energy intensive industries, which might be just the beginning of a strongly increasing trend in the coming years.

5.1.5. Energy and Gas Intensity

Energy intensity indicates how much output a country can create (measured by gross domestic product) for the energy that it puts in. The ratio is *Total Energy Consumption/GDP in US dollars,* which brings us to a number that describes the amount of energy consumed per US dollar. Similarly, gas intensity indicates how much output a country can create for the gas that it puts in and the ratio is *Total Gas Consumption/GDP in US dollars.*

Figure 84: Energy and Gas Intensity in the Industry in US



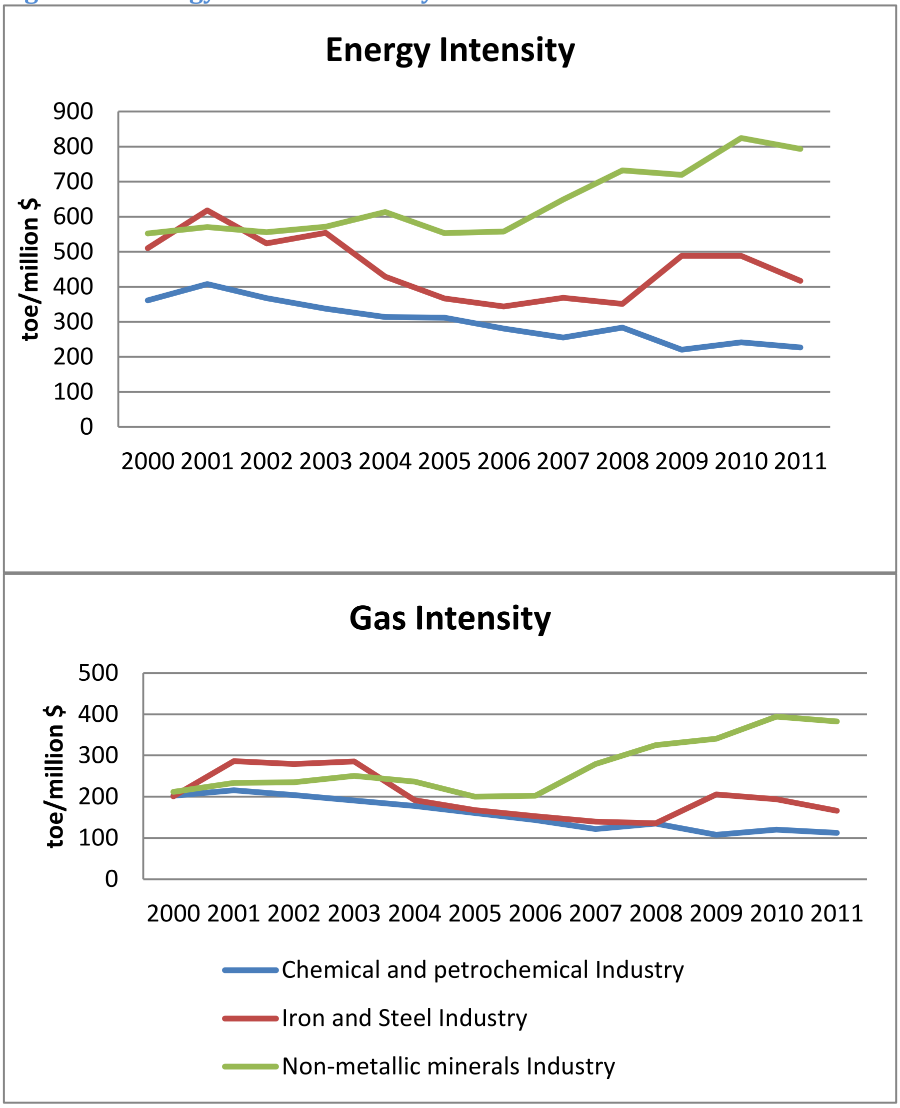
Data Source: IEA Energy Balance for OECD Countries

The energy intensive industries in US contain in their energy mix gas in a proportion of around 50%. Until 2005 the energy intensity decreased in the industry as a consequence of the US "des-industrialization" process when the greatest manufacturers companies were forced to move outside US for cheaper energy. The continued decline in energy intensity of the industrial sector is explained in part by a shift in the share of shipments from energy-intensive manufacturing industries (bulk chemicals, petroleum refineries, paper products, iron and steel, food products, aluminum, cement and lime, and glass) to other, less energy-intensive industries, such as plastics, computers, and transportation equipment, and also by the growth of the service sector relative to the manufacturing sector. As well, efficiency gains in all sectors decrease the energy intensity. Almost every manufacturing sector, energy intensive or not, has reduced its energy intensity since 1991 (Halpern &Lopp, 2007).

The same trend can be followed on the gas intensity indicator, as gas is an important source of energy in US. In the last 5 years gas intensity is slightly increasing, but there is no indicator that cheap shale gas has an influence here. Nevertheless, a decrease in energy intensity can be also an efficiency indicator in the production line in respect to energy consumption.

The graphs below show the same trend of energy intensity and gas intensity in three sectors of the industry. Therefore, we can affirm that these energy intensive industries are more specific, gas intensive industries. Chemical and petrochemical sector presents a slightly increase since 2009 in the gas intensity, increase that could be caused by a reorientation inside the industry upon the production of goods that require more gas consumption. However, the general trend of the sectors' gas intensity is decreasing since 2001, showing, besides an efficiency of the technological process, a switch of the focus towards high added value of products.

Figure 85: Energy and Gas Intensity in US



Data Source: IEA Energy Balance for OECD Countries

5.2. Case Study II: The impact of the lack of competitiveness in the natural gas market upon the industry's dynamics in Brazil

5.2.1. The context

Brazil presents a different story than US when it comes to natural gas. Natural gas is a relatively new sector in Brazil, which practically started with the construction of Bolivia-Brazil pipeline in 1999. Its contractual structure and the monopoly model lead to a problematic market situation. The main structural problems in the Brazilian gas market are the existence of a vertical dominant agent (Petrobras), the lack of infrastructure and the investment management for its development, the non-competitive prices that injure the industrial sector and the lack of planning and vision in short term.

For petrochemical industry, the high raw material prices and the third most expensive energy in the world represents the main impediment in a country where the last cracking facility was built in 1982. Moreover, the relative high cost of investing in Brazil, 25% higher than in China and 10% higher than in Mexico, the expensive and underdeveloped transport infrastructure and the lack of investments in R&D in industry, hinder the investments in the sector. Also, the natural gas prices driven down in US by the shale gas made it more difficult for Brazil to compete in products that are derived from natural gas. In addition to the high cost of basic inputs, the competitiveness of the manufacturing sector has also bottlenecks related to the cost of capital and labor.

The above-mentioned factors have pushed Brazilian petrochemical powerhouse Braskem to delay to 2014 its decision regarding its investment in Petrobras' COMPREJ, the largest planned project in the petrochemical industry, valued to $8.5 billion. The project would place Braskem close to the pre-salt oil reserves and it would additionally allow it to balance its raw material portfolio, which currently stands at 80% naphtha and 20% gas. Braskem also decided to delay another two polyethylene plants. Finally, Dow Chemical and Mitsui have postponed their largest investment in the country, a biopolymer plant in Minas Gerais. The high raw material prices have forced companies to shift production abroad, to countries where costs are lower. Braskem is currently investing $4.5 billion in a major petrochemical complex in Mexico, where gas prices are arbitraged with the US prices.

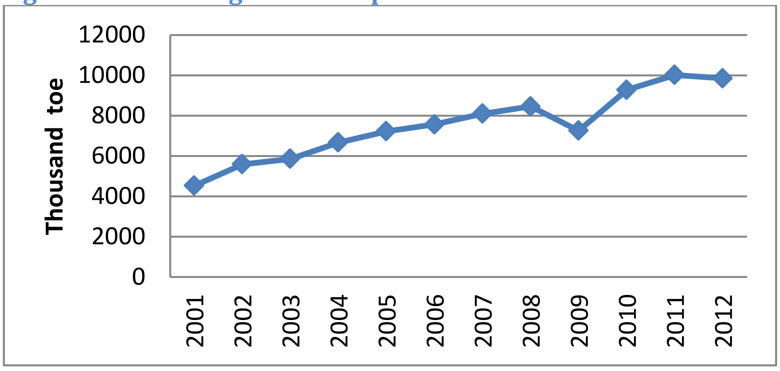
Crude oil and natural gas are, and have long been, the primary feedstock for the global chemical industry. However, there is an obvious trend towards renewable feedstock to produce "green" chemicals and Brazil has proved to be competitive and successful in using sugar (from sugarcane) for the production of commodity chemicals. Access to cost-competitive plant-based starting materials is a key source of competitive advantage for producers of renewably sourced chemicals and Brazil is a country with rich agricultural resources, proper for the development of bio-based chemical manufacturers.

Along with the energy costs, another factor is likely to influence Brazil's manufacturing industry competitiveness over the next several years: the physical infrastructure for commerce (Deloitte, 2012). The productivity of a country is directly influenced by efficient infrastructure such as roads, ports, electricity grids and telecommunication networks, which are vital for logistics, moving raw materials and finished products on time and with minimum costs. As host to the World Cup in 2014 and the Olympics in 2016, Brazil is expected to improve infrastructure and bring in foreign investment, which will likely also have a positive influence on improving the country's manufacturing industry and competitive position.

5.2.2. Gas Consumption in Industrial Sector

In Brazil the natural gas consumption is substantially lower and accounts for only 11% of industrial energy mix in 2012. The industrial demand is increasing continuously over the period of 2001-2008, drops in 2009 with 1200 thousand toe from the previous year, but it recovers in 2010 at even higher levels. In the last two years, due to the very high natural gas price, the consumption is rather constant.

Figure 86: Natural gas consumption in Industrial sector in Brazil



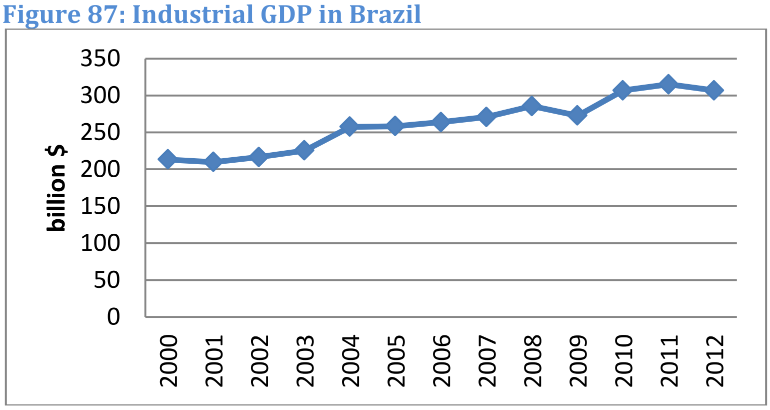
Data Source: BEN-Brazilian Energy Balance

The drop in the gas consumption in industry both in US and Brazil in 2009 is due to the strong economical crises in that year worldwide, and the increase in 2010 is more related to the crisis recovery than to the evolution of prices. This is also proven by the drop in the industrial GDP in 2009.

5.2.3. Industrial GDP

Brazil was in 2011 the sixth-largest economy in the world, 27.5% of its GDP being represented by the Industry. After the drop in 2009, it increased with 13% until 2011, but in the last year decreased with 3%.

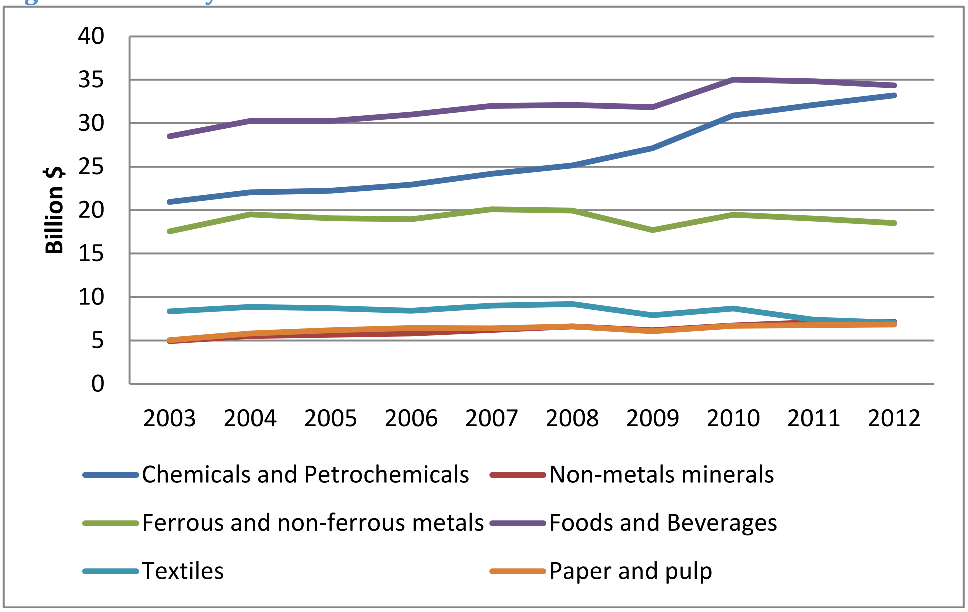
Figure 87: Industrial GDP in Brazil



Data Source: IEA database

Unlike the US situation, the economic crisis is seen much less in Brazil and as the GDP dropped in 2009 only in two of the sectors that we analyze: ferrous and non-ferrous metals and textiles industry.

Figure 88: GDP by Sector in Brazil

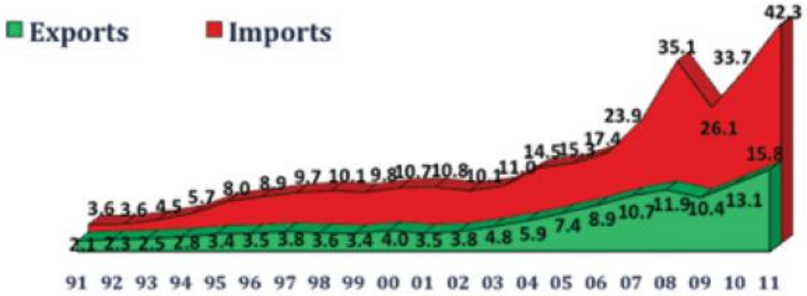


Data Source: Brazilian Energy Balance 2013

Despite the non-competitive gas price, Brazil's chemicals industry stands seventh in the world. It is a key segment of the national economy, generating about 3% of the GDP. As we can see in Figure 88, Chemicals and Petrochemicals are a very promising boon in the Brazilian's GDP, despite its first slight contraction in four years. Despite expensive raw materials and trade deficit of $29 billion in 2012, Brazil's chemical sector nonetheless remained the country's fourth largest contributor to the economy in 2012, with sales of $153 billion (IHS Chemical, 2013).

According to figures released by Abiquim, the Brazilian chemical industry association, Brazilian production of industrial chemicals was up by 2.89% in 2012 compared with the year before, while net sales increased 23.4%. Brazil's increased consumption of chemicals in recent years was largely supply by imports. While the overall growth rate of the chemical industry was of 7.7% in 2011, the chemical production shrank by 2% and imports grew by 27.9%. This is due to the fact that investments in chemical sector have been far below the needs of the country over the past two decades. Even if chemical imports fell during 2012, they still represent one-third of the domestic market (IHS Chemical, 2012).

Figure 89: Trade balance of chemical products 1991-2011

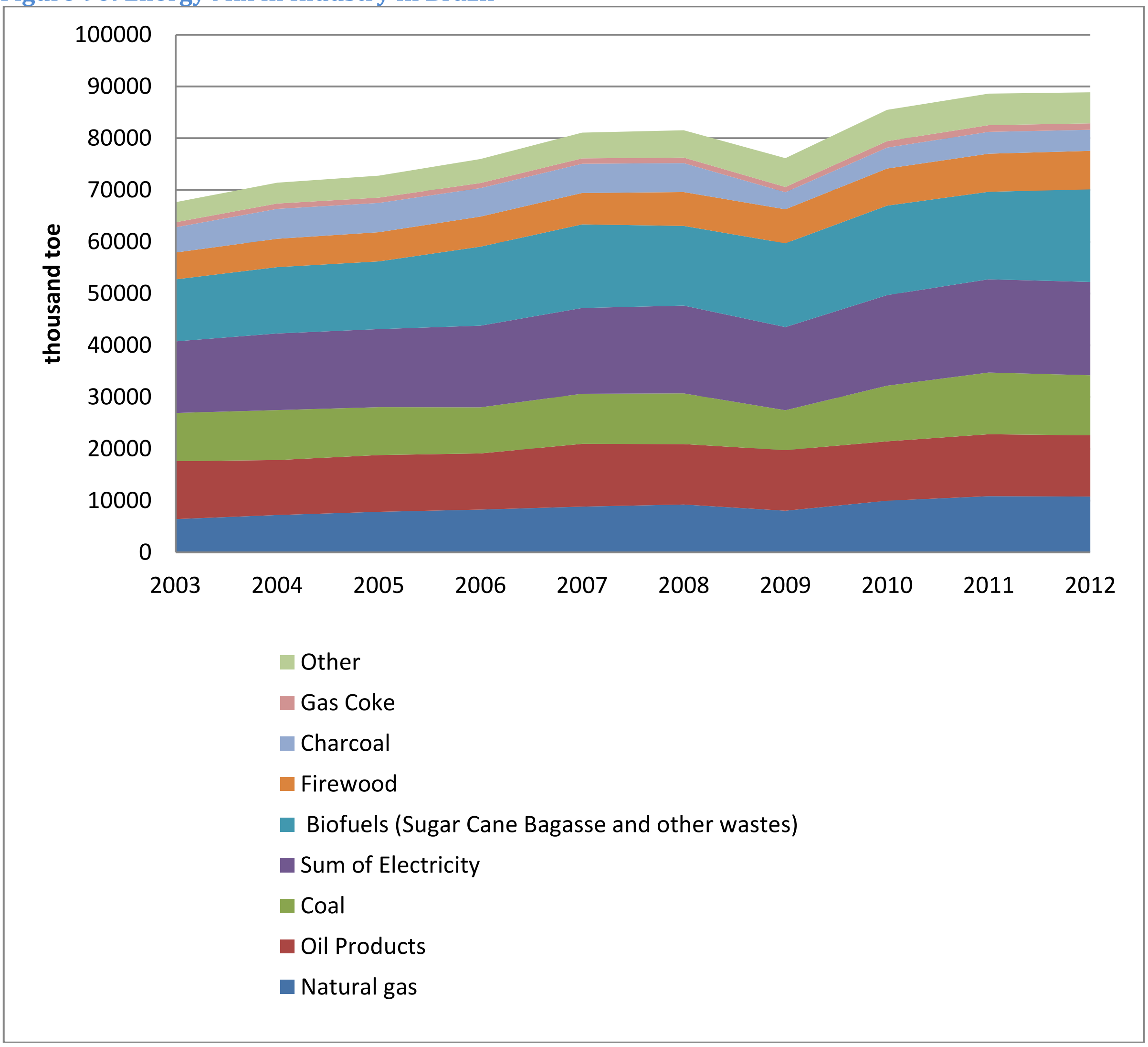


Source: ABIQUIM

5.2.4. Energy Mix

In Brazil, natural gas has a very low contribution in the industry. However, it is maintained at relative constant levels, increasing from 2003 to 2012 only from 9.5% to 12.1% in energy mix share.

Figure 90: Energy Mix in Industry in Brazil

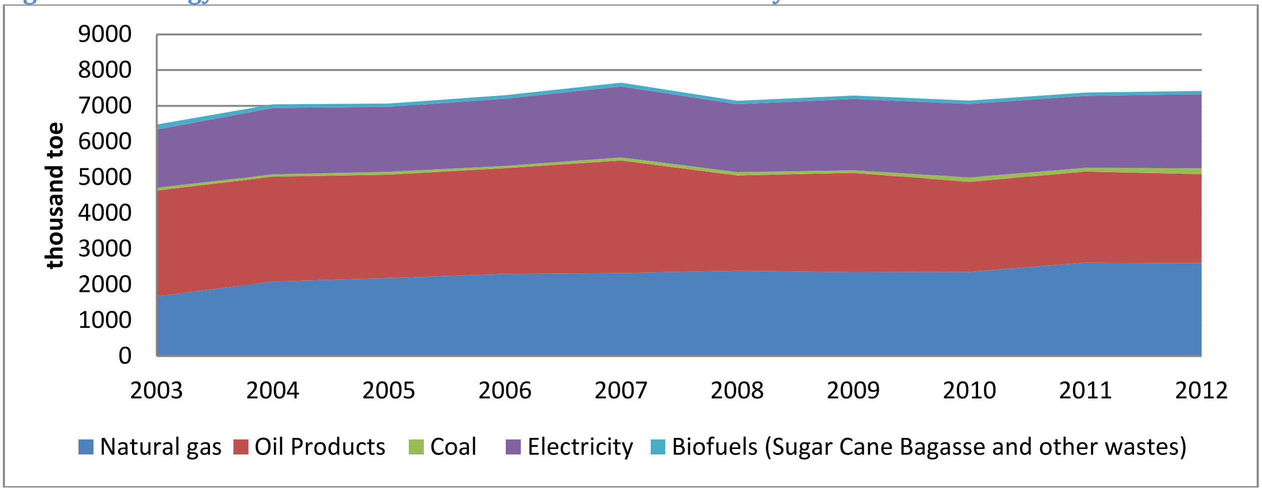


Data Source: Brazilian Energy Balance 2013

Natural gas has a much lower contribution in energy matrix in Brazil than in the US, due to both very high gas prices and the fact that Brazilian natural gas market is much more underdeveloped. However, Brazilian regulation is trying to incentivize the development of natural gas industry and its utilization in industrial sector as well as in power generation.

In chemical and petrochemical industry, natural gas share increased from 2003 to 2012 with 10%, with relatively low variations.

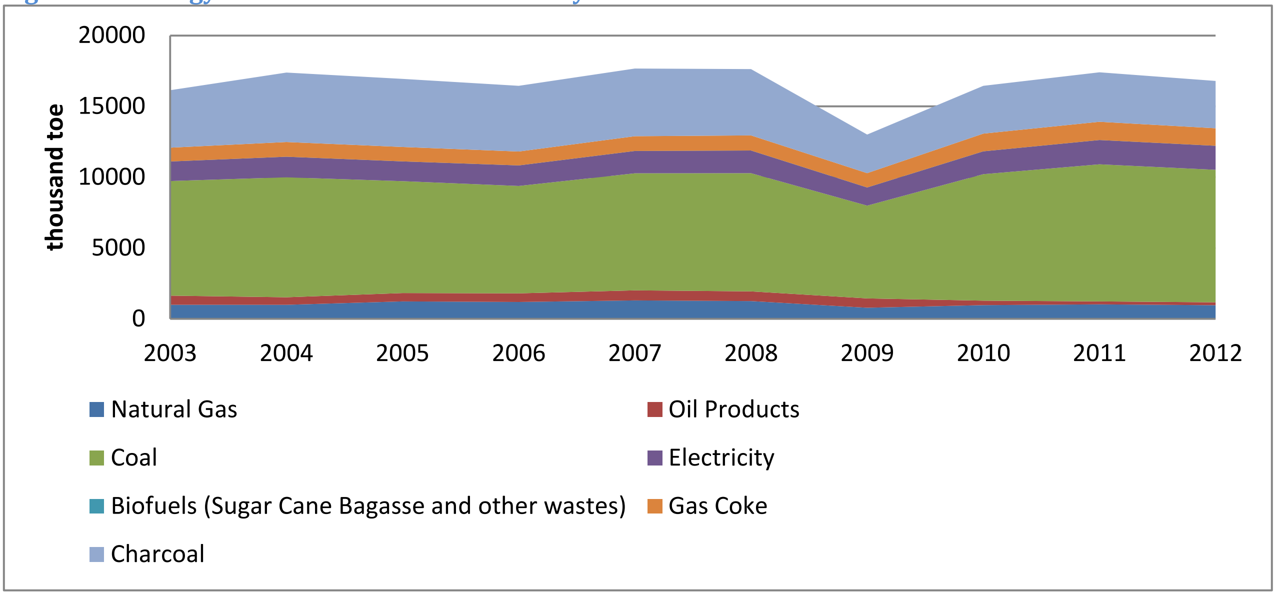
Figure 91: Energy Mix in Chemicals and Petrochemicals Industry in Brazil



Data Source: BEN-Brazilian Energy Balance 2013

Iron and steel industry utilize natural gas in a proportion under 8%, being in a constantly decrease since 2005.

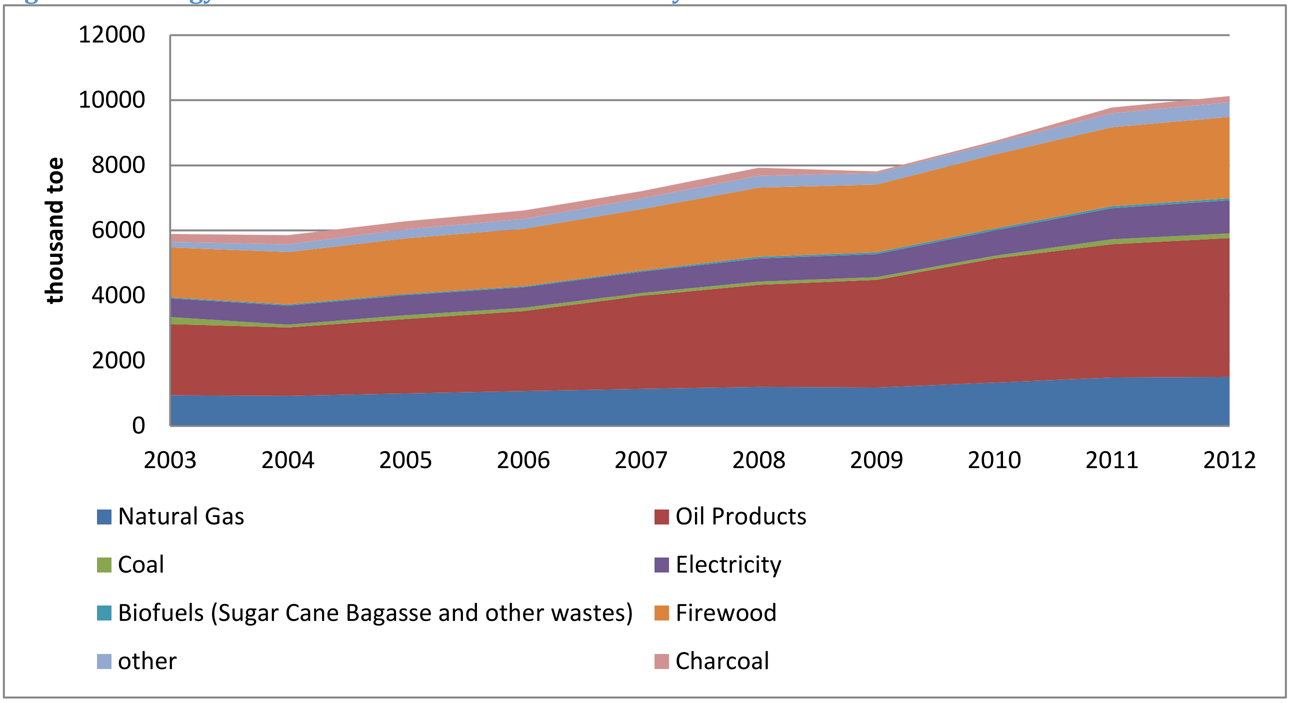
Figure 92: Energy Mix in Iron and Steel Industry in Brazil



Data Source: BEN-Brazilian Energy Balance 2013

In the non-metallic industry in Brazil the natural gas contribution at the energy matrix is constant at 15% since 2003 until present.

Figure 93: Energy Mix in non-metallic minerals industry in Brazil

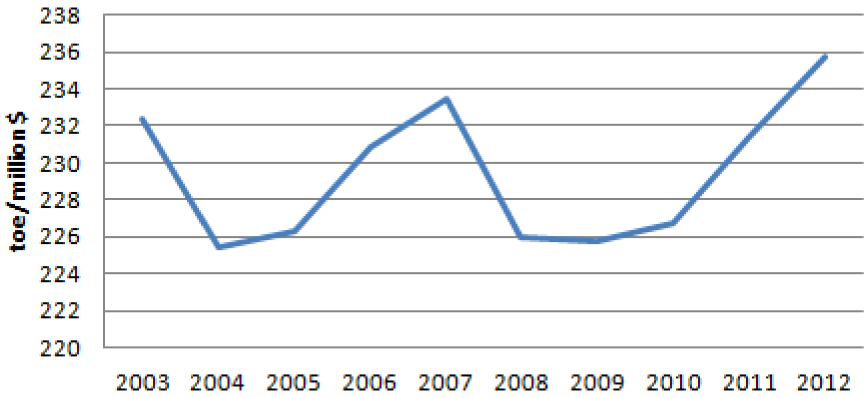


Data Source: BEN-Brazilian Energy Balance 2013

The energy intensive industries in Brazil include in their energy matrix only in a very low proportion natural gas, and its share is rather constant over the last 10 years.

5.2.5. Energy Intensity and Gas Intensity

Figure 94: Energy Intensity in Brazil 2003- 2012

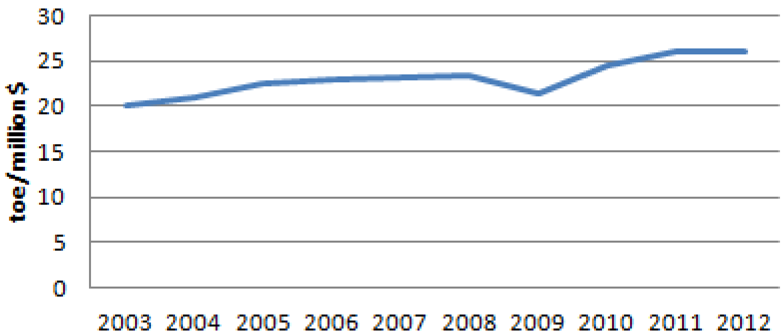


Data Source: BEN-Brazilian Energy Balance 2013

Brazil has a more energy intensive industry than US, as energy-intensive sectors have played an important role in the Brazilian economy. In the 1970's, after the first oil shock, the government's strategy to strength the national industry places the intermediate goods, energy and transport sectors in the core of the development process. The goals were to transform natural resources in currency, substitute imports for domestic goods and minimize the problems from the first oil shock. To implement this strategy, government and private investments were channeled towards the energy sectors (Petroleum, Coal and Gas, Electricity) and intermediate goods (Metallurgy of Iron, Steel, Aluminum and Others; Chemical) (Santos, Haddad, Guilhoto, &Imori, 2008). Since then, energy-intensive activities play an important part in Brazilian industry.

The energy-intensive sectors are the sectors in which energy represents more than 10% of the intermediate inputs costs. These sectors in Brazil are: Mining; Food and Beverage and Tobacco; Paper and Pulp; Chemical, Rubber and Plastic Products; Cement; Ceramic and Glass; Metallurgy of Iron and Steel; Metallurgy of Aluminum and Copper. The industrial production in Brazil was responsible for 28.2% of the national GDP in 2012 and the energy-intensive sectors represented 40.6% of this industrial production.

Figure 95: Gas Intensity in Brazil 2003-2012



Data Source: BEN-Brazilian Energy Balance 2013

Despite the fact that industry in Brazil is more energy intensive than the industry in US, it is not more gas intensive. The energy intensive sectors in Brazil are a direct consequence of the electricity intensity. Gas costs are the fourth highest in the world, seriously harming some industrial sectors, such as chemicals. It terms of energy, Brazil has become very expensive.

Conclusion

The shale gas revolution decreased natural gas prices in US at levels that few years ago no one imagined. Soon after, studies on the sustainability of the shale gas, on the future of these reserves and on prices forecasts start being made; press releases worldwide articles under grandiose titles as "Shale Boom Sparks US Industrial Revival", "Long-Term Advantage For U.S. Chemical Industry Due To Shale Gas Revolution" or "the end of <<Made in China>> Era" and not much later, big, international companies announce their new investments plans in US. Meanwhile, Europe and China are desperately trying to drill for their shale gas hoping for the same price advantage. This first happened in 2009 and 4 years after, IEA and EIA's numbers doesn't share the same impact. The consumption of natural gas in the most energy intensive industry barely increased few percent, which rather is explained by the recovery after the economic crisis than by the revolutionary rock; the gas used as a feedstock is, on the contrary, decreasing in the lasts years, and if energy and gas intensity is increasing in some industries, this happens since 2005 when prices were at their highest levels.

An immediate conclusion would be that the industrial competitiveness today in US is just overstated, as no actual impact of shale gas is seen in the country's GDP, gas consumption and energy mix. However, giving a more careful look, the real change might be felt only from now on: firstly, because millions of dollars investment decision are not made the second day prices drop; secondly, because an immediate reaction could be given only by the idle existent capacity combined with the just recovered after crisis local demand. Some industries as the chemical and petrochemical industry and iron and steel, which were able to extend their demand externally and export, have indeed contributed more to the industrial GDP in the last 3 years. But for the moment, the limit is the existent capacity. There cannot be more production and more consumption than the plants allow to, and plants construction takes around 4-5 years from the moment is start building it. Specialists say that the competition from Americans will only get tougher as the new plants come on stream, mostly over the 2017-2020 periods. Moreover, 5 years ago, US was prepared to become an even more heavily gas importer and it disposes of plenty of regasification plants, but none of liquefaction. The construction of these facilities takes as well 4-5 years, as the firsts exports are forecasted for 2015. Therefore, the abundance of domestic gas that can be exploited at relatively low cost dropped the gas prices, but it needs time for a whole, huge industry to react to such a sudden and unforeseen change. The way from China back to US is long and full of uncertainties, but it seems that for a number of companies is worthy. Therefore, a wiser conclusion to the data analyses of the US case would be that such a quick react to an infancy industry as shale gas drilling cannot be expected. However, if gas prices will maintain themselves decoupled for a long period of time, US will continue to gain more investors from overseas.

Whereas there is significant evidence that low prices is helping gas intensive industries in US, the negative impact of the Brazilian expensive gas price in the industry seems to be overcame by other factors. Being on the seventh place in the world, chemical industry registered an increase of 23.4% in the net sales in 2011, where the greatest boost was seen amongst fertilizers, in which sales have almost doubled ($11.5 billion) and among industrial chemicals, which grew 24.5% from $61.2 billion. All these took place in spite of high gas prices.

Underdeveloped infrastructure, high energy prices, shortages of raw materials at high prices, taxes, interest rates and exchange rates, coupled with a lack of investment over the last two decades, surely doesn't result in a competitive industrial sector. It results in a domestic production that remained below demand and a lack of qualified jobs, hindering the possibilities of technological development, pivotal to fully exploiting the potential of the sector. However, five years ago, Brazil was the 10^{th} largest chemical industry and now it is the 7^{th}.Unlike the petrochemical sector of US that is growing driven by the market forces, the success of the Brazilian petrochemical sector is regulated. Brazilian industry is, in general, a large and very protected industry, as imported products are highly priced. Therefore, the domestic market is large and dynamic enough in order to feed one of the greatest industries. To this we can add solid economic fundamentals, a perspective of sustainable long-term expansion, and the country's pre-salt oil exploration and by biomass potential. "Brazil offers a very good and valuable financial sector, a legal system that is reliable, stable institutions, political stability and a huge internal market. Brazil is a place that any player with ambition of being a global player has to be. There is no way to be global and not be in Brazil", affirms Alexandre Bertoldi, from leading law firm's PinheiroNeto. However, at the moment, the Brazilian industry is not competitive in a global scenario, but is huge because of the internal market and the recent local economic growth.

Final Chapter: Conclusions

Starting from the shale gas event that represents a game changer for United States economy, the present dissertation analyses to what extent gas prices can influence the industrial competitiveness of a market. Being a market historically defined by its regional character, the applicability of Law of One Price in the gas market is not straightforward. Therefore, the thesis treats the impact that the price difference between markets has upon the industry's growth and how it influences the industry's dynamics.

First part of the thesis is dedicated to the possibility of achieving a global gas market and price in the near and middle term. Law of One Price is an economic principle stating that when arbitrage between regional markets exists, the price differences of the commodities should only reflect the transportation and transaction costs between the markets. Natural gas industry falls in the case of network industries, for which law of one price is not obvious, as arbitrage is more difficult reached. Traditionally, world gas markets have operated as three largely self-contained regions: North American Market, Europe – supplied by Russia and Africa, and Asian Market –linked to Middle East. Until 2008, prices in these markets were coupled at around 12.5 $/MMBtu but different factors led to this great price differences in the last 5 years: shale gas exploration drove prices in US at 3.7$/MMBtu, nuclear closure in Japan increased gas prices to more than 16$/MMBtu, while Europe kept prices at around 10$/MMBtu.Since then, arbitrage opportunities aroused together with industrial competitive advantages in low priced gas markets.

The future evolution of the regional gas prices is of a great importance for the industry's dynamics. In this sense, the thesis analysis the drivers and constrains of achieving a global gas price by building a typology that takes into account the future LNG trade, regional supply, demand and price formation mechanisms.

Link between markets can be achieved through pipelines and LNG trade. Even though pipeline accounts today for almost 80% of interregional gas trade, the LNG share trade is expected to grow, as it is much more advantageous over long distances. LNG offers the potential for a great diversity of suppliers and markets through the flexibility of choosing the routes. However, the transportation capacity is very limited, the facilities construction are expensive, making thus improbable to obtain a price convergence resulted from a better market connection in the following years. Besides that, even if US will export enough gas to make an impact on the gas prices in importing countries, its gas won't be much cheaper. Adding to the Henry Hub price the cost of liquefaction, regasification and transportation, will increase the receiving LNG cost at the actual levels in Europe and slightly below the prices in Asia.

Nevertheless, gas prices are strongly driven by internal factors that characterize each regional market. One of the reasons for such a price divergence is the different pricing mechanism used in each regional market. In general, US has gas-on-gas competition, open access to pipeline transportation and manages risk through spot and derivatives markets. The European market relies more heavily on long-term contracts linked to oil price, and its pipeline access is restricted. Asia uses long term contracts benchmark priced to crude oil; this structure has kept LNG prices in Europe and Asia high relative to other regions. These market features, along with the availability of domestic natural gas resources and geopolitical interests, established the boundary conditions for the development of global natural gas markets.

In US, supply and demand will balance at a lower price compared to prices abroad. While Europe might miss the shale gas revolution, its demand is slightly decreasing as a result of chemicals industry shift to US and of coal replacing gas in power mix generation. Asian gas demand is maintained at high levels due to anti-nuclear policy to be adopted in Korea, Japan and Taiwan. Therefore, prices are kept high. Nevertheless, the shale potential in China, the gas reserved recently discovered in East Africa and new exports from Australia, in addition to possible exports from Russia, who is searching for new markets, are putting downward pressure on Asian prices.

Even if pressures to homogenize prices exist, a global gas price won’t be reached in the medium term. The main factors that impede market integration include the political goals of the current and future main natural gas exporters and the high transportation barriers.

Second part of the dissertation deals with the impact of this price differences upon the industry's dynamics, especially upon the gas based industries, in which the cost of gas is significant in the total cost structure. US market presents abundant gas supply at relatively low cost in a political risk free country. As a result, US had gained significant competitive advantage that seems to be able to reshape the nation's industry. In the wake of the shale gas boom, 110 new investment projects were announced for the US, worth of $77 billion. It came to the discussion of a possible reindustrialization of the country and thus the end of <<Made in China>> Era. Meanwhile, Europe and China are seeking the same opportunities, trying to drill for their shale gas and hoping for the same price decrease.

However, the data analysis shows that until today a considerable change in the energy mix and industrial GDP in US has not been observed. The difference between the optimism regarding US industry and the numerical indicators of the evolution of this industry could be explained by the time delay between announcing the investments and the actual implementation of the new projects. An immediate change in the industry's indicators could be given only by the idle existent capacity combined with the just recovered after crisis local demand. Some industries such as the chemical and petrochemical industry and iron and steel, which were able to extent their demand externally and export, have indeed contributed more to the industrial GDP in the last 3 years. But for the moment, the limit is the existent capacity. There cannot be more production than the plants allow to and plants construction takes around 4-5 years from the moment is start building it. Specialists say that the competition from Americans will only get tougher as the new plants come on stream, mostly over the 2017-2020 periods.

On the other hand, this thesis analyses the case of Brazil in order to assess the evolution of the industry in a country where gas market is lacking competitiveness. The negative impact of the Brazilian expensive gas price in the industry seems to be overcome by other factors. Underdeveloped infrastructure, high energy prices, shortages of raw materials at competitive prices, taxes, interest rates and exchange rates, coupled with a lack of investment over the last two decades, surely doesn't result in a competitive industrial sector. It results in a domestic production that remained below demand and a lack of qualified jobs, hindering the possibilities of technological development, pivotal to fully exploiting the potential of the sector. However, the Brazilian chemical industry is on the seventh place in the world, having registered an increase of 23.4% in the net sales in 2011. The impact of high gas prices are therefore overcome by one of the largest and most dynamic domestic markets in the world, by solid economic fundamentals and by a perspective of sustainable long-term expansion. When all these are complemented by a very good and valuable financial sector, by a reliable legal system, by stable institutions, political stability and a huge internal market, the negative effect of high gas prices is diminished. Nevertheless, important is to mention that Brazilian industry is well protected by the government, which makes imports much more expensive than internal production. Therefore, it can be referred to the industry in Brazil as a huge industry, but not as a global competitive industry, as it is the US case.

It can be therefore concluded that natural gas price is significant for some industries, it can impact to some extent the industry's dynamics around the world, but is not the only important factor. Low gas prices help achieving more easily a desirable level of industrial competitiveness, but the absence of it doesn't result in the lack of industries in the respective country. Therefore, the impact of shale gas' emerge in US upon the global industry's dynamics might be overstated at this point. Other factors that create competitive advantages, as political regime, country's local policies and taxes, available infrastructure, workforce and technology, market size and growth and closeness of the consuming market, easiness of trading across borders can be equally important.

The present dissertation concludes that the gas price differences between the three main regional markets will persists in the upcoming years, conferring thus an incentive to gas based industries to invest in US and profit of the cheaper gas. However, cheap gas is not the only condition for industrial competitiveness, being complemented by available and political risk free environment is essential. Besides these three criteria, US presents other favorable factors that incentivized the present reindustrialization process. Nevertheless, the comparison analysis done on the US and Brazil cases shows that, despite its expensive gas and underdeveloped gas market, the Brazilian industry is growing, helped by government protection and by a great domestic market. Industry's dynamics cannot be explained by energy, but it is one of the factors that count in decision making process.

However, the study has some limitations, given mainly by the availability of the very recent data. As it is considered that shale gas is making his impact visible in the industry starting with 2013, most of the indicators that have been used in the analysis are not yet available for the last months.

The present thesis opens the path for further studies in order to improve the understanding of the industry dynamics. First of all, a better understanding of the economies of shale gas can be achieved, as so far there is not a clear verdict on how sustainable is the present price regarding to costs. Then, the industry dynamics can be analyzed using more indicators or by assessing how investment is driven by the price of energy, in more general terms.

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Annex A

Company	Headquartered
3M	US
Aither Chemicals	US
Appalachian Resins	US
Ascend Performance Materials	US
Agrium	Canada
Arkema	France
BASF	Germany
BioNitrogen	US
Bayer Material Science	Germany
Braskem	Brazil
C3 Petrochemicals	US - Houston
Celanese	US Dallas- Texas
CF Industries	US
Chevron Philips	US Texas
CHS	US Minnesota
Cytec Industries	US
Sinopec - China Petrochemical Group	China
Dow Chemical	USA
DUPont	US
Eastman Chemical	US
Evonik Industries	Germany
ExxonMobil Chemical	US
Formosa	China
G2X Energy	US
Georgia Gulf	US
GrupoMissi&Ghisolfi	Italy
Honeywell Speciality Materials	US
Hanwha Chemical	Korea
ICL Industrial Products	Israel
Indorama Ventures	Thailand
INEOS	Switzerland

Invista	US
Koch Industries	US
Kuraray Americas	US
LANXESS	Germany
Lubrizol	Brazil
LyondellBasell	US
MEGlobalMexichem/Oxyxhem	Mexico/ US
Methanex	Canada
Mitsui&Co	Japan
Noltex	US
Occidental Chemical	US
Ohio Valley Resources	US
Orascom Construction Industries	Egypt
PCS Nitrogen	US
PetroLogistics	US
PTT Global Chemical	Thailand
Renetch	US
SABIC	Saudi Arabia
Sasol	South Africa
Shell Chemical	Netherlands
Shintech	US
Solvay	Belgium
US Nitrogen	US
TPC Group	US
Westlake Chemical	US
Williams	UK
Yara	Norway
YPF	Argentina

Table 9: Companies that have announced shale-related chemical industry investments