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Gas Price Formation, Structure & Dynamics

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CONTENTS

Introduction

Our study, focused on gas prices in importing economies, describes wholesale prices and retail prices, their evolution for the last one or two decades, the economic mechanisms of price formation.

While an international market for oil has developed thanks to moderate storage and transportation charges, these costs are much higher in the case of natural gas, which involves that this energy is still traded inside continental markets. There are three regional gas markets around the world: North America (the United States, importing mainly from Canada and Mexico), Europe (importing mainly from Russia, Algeria and Norway) and Asia (Japan, Korea, Taiwan, China & India, importing mainly from Indonesia, Malaysia & Australia). A market for gas has also developed in South America, but it will not be covered by our paper.

In Europe and the US, due to large domestic resources and strong grids, natural gas is purchased mostly through pipelines. In Northeast Asia, there is a lack of such infrastructures, so imported gas takes mainly the form of Liquefied Natural Gas (LNG), shipped on maritime tankers. Currently, the LNG market is divided into two zones: the Atlantic Basin (Europe and US) and the Pacific Basin (Asia and the Western Coast of America). For the past few years, the Middle East and Africa have tended to be crucial suppliers for both LNG zones.

Gas price formation varies deeply between regional markets, depending on several structural factors (regulation, contracting practises, existence of a spot market, liquidity, share of imports…). Empirically, the degree of market opening (which corresponds to the seniority in the liberalization process) seems to be the primary determinant of pricing patterns.

North America has the most liberalized and well-performing natural gas industry in the world. Gas pricing is highly competitive and is based on supply/demand balances. Spot and futures markets are developed. The British gas sector is also deregulated and thus follows a similar paradigm. Gas-to-gas competition now prevails. Long-term contracting is still the dominant model in Continental Europe and Northeast Asia, because of their dependence on external imports. Thus, pricing there is more rigid, and due to an indexation clause, gas prices closely follow the tendency of oil markets (as we will see further, American and British prices are also coupled to oil, but for less contractual reasons).

Logically, the first part of our study analyses North American gas prices, the second part European prices and the third part Asian prices. Since American and British gas markets exhibit the same nature and similar pricing features, it would be more relevant to treat them together. However, if these two markets are close conceptually, there is no specific price connection between them. Indeed, due to the presence of the Interconnector, a pipeline passing under the Channel, UK prices tend to be rather linked to the European Continent's. Therefore, in our paper, the case of the UK is simply studied inside Europe, although in a dedicated paragraph.

While observing mid and long-period price series, we will obviously seek common trends, since price integration (convergence or simple correlation) is generally evidence in favor of market integration. Price indications will thus guide us with a view to answer two crucial questions:

1) Did liberalization policies succeed in the US and EU, in their attempt to make natural gas a freely traded commodity?

2) Is a world market for gas emerging? In other words, is natural gas becoming a worldwide traded commodity?

The first question concerns intra-regional integration of markets: common price trends between local spot markets (in the case of the US), between member states (in the case of EU), and between piped gas and LNG (in both cases).

The second question concerns inter-regional integration of markets. In this view, the case of LNG will be of an overriding importance. Indeed, the higher technical flexibility of the LNG supply chain implies rising LNG international arbitrage, cargoes being diverted to the most profitable destinations. Co-movements are then expected between regional quotes, leading to the potential emergence of a world gas market with a single price.

Methodological note

In order to facilitate comparisons, all prices (wholesale and retail) have been converted into a common unit: dollars per millions of British Thermal Units ($ / MBtu). Also, in order to flatten the usual volatility or seasonality in gas prices, we always use yearly average prices.

All prices displayed in figures, tables and text are nominal values (except figures n°11 and 13: prices are expressed in dollars of 2000). Using market prices (which integrate inflation) is suitable for the present study. Indeed, the presence of inflation doesn't impede the analysis of price determination or structure. Regarding price trends over time, inflation, with its distorting effect, can become more problematic. Real prices, deflated through constant values, usually offer a clearer vision of gas sector fundamentals (for example, constant prices are required in order to assess the evolution of the balance between reserves, production and consumption). However, more than the sense of trajectories, this paper tries particularly to check the parallelism between them (between spot and import prices for example) and from this point of view, inflation (an overwhelming, macroeconomic effect) doesn't interfere.

North America

1) A brief history of prices and regulation

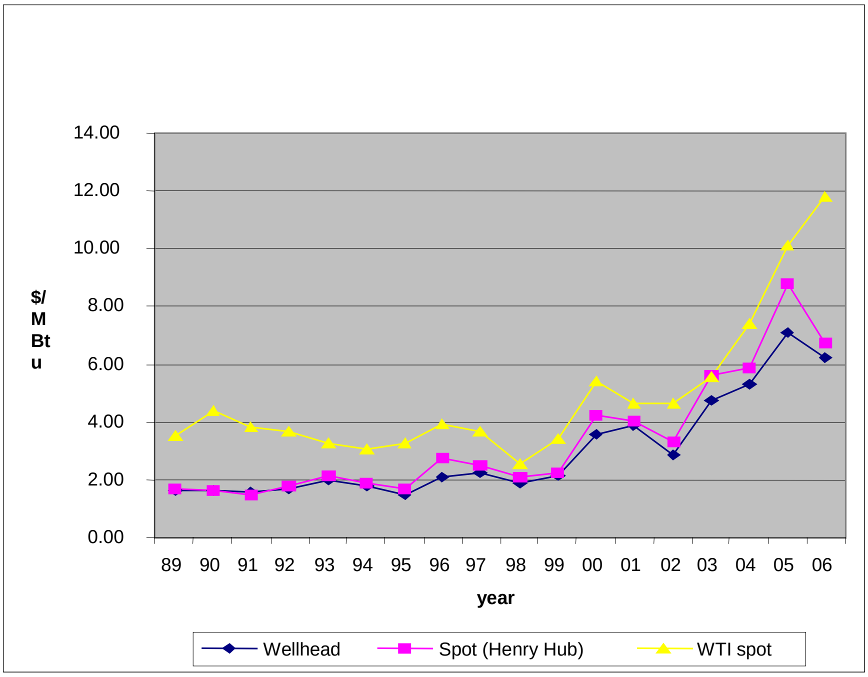
The Natural Gas Act of 1938 orders companies to charge "cost-of-service" rates for interstate gas trade. Such quotes consist of historic costs plus a reasonable return on investment *(ETC, 2007)*. In 1954, a Supreme Court Judgement extended control to wellhead prices, but only regarding gas sold by interstate pipelines. As a result, price distortions occur between interstate and intrastate markets on the one hand, and between gas and energies such as oil and coal on the other hand.

A partial deregulation of wellhead prices occurred in 1978 with the Natural Gas Policy Act. But in the meantime, international energy prices soared due to the oil shocks, so when full de-regulation finally became effective seven years later, gas rates rose suddenly, creating an extended market surplus called "the gas bubble", which lasted until the mid-1990's *(ETC, 2007)*.

At the beginning of the 1980's, gas transactions were long-term contracts between producers, pipeline traders and Local Distribution Companies (LDC), including a minimum bill provision in order to secure the value chain. In 1984, the Federal Energy Regulatory Commission (FERC) Order n°380 released utility buyers such as LDC from the commitment to purchase the transportation capacity they reserve, which led to a deep fall in average wellhead prices. Consequently, from 1986 until 2000, demand resumed its growth with major reliance on imports from Canada *(ETC, 2007)*. Figure n°1 thus shows that American wholesale prices rose steadily over the period: the yearly average spot price at the Henry Hub swelled from 1.70 $ / MBtu in 1989 to 2.75 $ in 1996.

During the winter 2000-01, gas prices peaked to more than 4 $ / MBtu because of a structural supply shortage (Canadian exports were not sufficient to fuel the increase of the US gas demand) *(ETC, 2007)*. Between 2001 and 2005, an upward thrust occurred in gas prices, in line with the "third oil shock": Henry Hub quoted average 8.80 $ / MBtu in 2005. Since spring 2006, the gas market has slackened a bit, and so have prices.

Figure n°1: Wholesale average prices of natural gas in US (1989-2006)



Source: US DOE, BP Statistical Review & Energy Prices & Taxes

2) Gas price trends

The North American market for gas consists of the United States, Canada and, to a lesser extent, Mexico. The US natural gas market is competitive, liquid and transparent, to such an extent that gas-to-gas competition now prevails. But this physical spot market is frequently volatile. Therefore, since 1989, agents manage price fluctuation risks with futures contracts on the New York Mercantile Exchange (NYMEX).

Henry Hub, a major pipeline junction in Louisiana is the reference point of the North American pricing system; rates for other hubs are defined by difference from it. These quote gaps (called "basis differentials") reflect the transportation costs required to bring the gas to Henry Hub, but also correspond to market conditions at different national hubs *(ETC, 2007)*.

Although American gas prices are set by supply/demand equilibriums, independently from any reference to oil, they run parallel to petroleum trends in the long run. Indeed, due to inter-energy substitution effects at the end-use side, monthly gas prices range inside a corridor formed by a lower limit, heavy fuel rate, and an upper limit, light fuel rate. Indeed, in case of a gas price spike, households switch to light fuel oil, large industries switch to heavy fuel oil and power plants switch to coal *(Maisonnier, 2005)*.

More precisely, the Energy Treaty Charter states that since the restructuring of the North American gas industry, gas-to-gas competition is the dominant pattern when the sector is in surplus, but when the market tightens, the correlation reappears due to inter-fuel replacements. For instance, when the American gas market was still at ease during the first part of the 1990's (period of "gas bubble"), gas rates evolved in quite a different manner than a barrel of West Texas Intermediate (WTI) (figure n°1). Since the end of the 90's and new restrictions on gas supply in the US (fading domestic production), they seem to be moving more in line.

3) Integration of spot and futures prices

Several empirical studies (de Vanys & Walls 1993 & 1994, King & Cuc 1996, Cuddington & Wang 2006, Park, Mjelde & Bessler 2007) suggest that liberalization policies (pipeline open access since FERC order n°436 in 1985), by reinforcing spatial arbitrage activity in the long run, have strengthened the US gas market integration. A common finding is that the number of co-integrated local markets has increased within the 5 to 10 years following the reform. This convergence is simply proved by the rising price spread correlations between geographical locations. Finally, Serletis & Rangel-Ruiz (2004, cited by Park, Mjelde & Bessler 2007) conclude that North American natural gas prices are largely defined by Henry Hub price trends. Nevertheless, King & Cuc (1996) and Cuddington & Wang (2006, cited by Park, Mjelde & Bessler 2007) discover an East-West spit inside the North American natural gas market, since the Western side seems to be weakly integrated within the rest of the country.

To summarize, the North American gas sector is a single, fully liberalized, highly competitive and strongly integrated market. This spot market maturity should then bolster the futures market efficiency in its capacity to integrate the sum of private information and expectations concerning gas supply and demand. In other words, prices as formed in the futures market should represent an accurate forecast of future spot prices. Indeed, Walls (1995, cited by Wong-Parodi, Dale & Lekov 2006) finds that gas futures prices are unbiased predictors of future spot prices. Wong-Parodi, Dale & Lekov (2006) state that the futures market is a more accurate predictor of natural gas prices within a two-year horizon than is the Short-Term Energy Outlook (STEO) of Energy Information Administration. As an explanation, Henry Hub forward prices are determined economically by the agent's expectations while the STEO derives analytically from an extrapolation of past price trends.

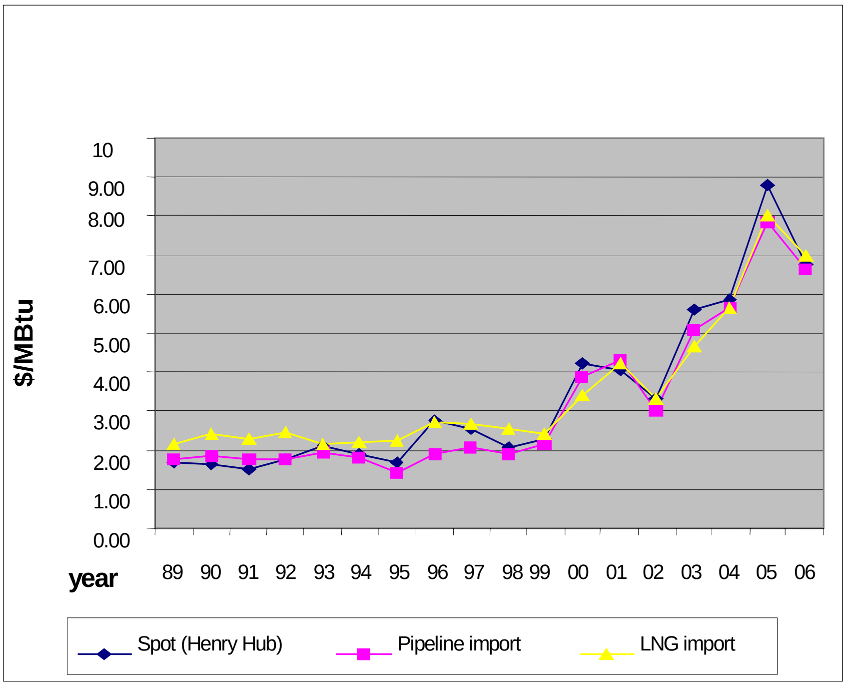
However, Felder (1995) affirms that the deregulation of gas industries has created new price volatility, and therefore one should give up deterministic approaches of price forecasting and opt for random walk models.

4) LNG prices

North America is part of the Atlantic Basin LNG market (with Europe). But in America, LNG trade is encompassed in the overall competitive evolution that affects the whole gas and electricity sector. As a result, LNG price determination is more or less disconnected from oil reference, and follows the trends of the existing gas-to-gas competition in the US.

Figure n°2 confirms this statement: pipeline import prices and LNG import prices follow a similar trajectory, which is given by market conditions at Henry Hub spot. As for an explanation, LNG is imported through short-term contracts on a netback basis, including a constant reference to gas market yardsticks like Henry Hub *(ETC, 2007)*. More generally, such common movements between LNG, piped and spot gas (econometrically proved by Siliverstives, l'Hegaret, Neumann & von Hirschausen, 2004) have witnessed the better integration of American gas prices since the industrial deregulation.

Figure n°2: Average import prices of natural gas in US (1989-2006)

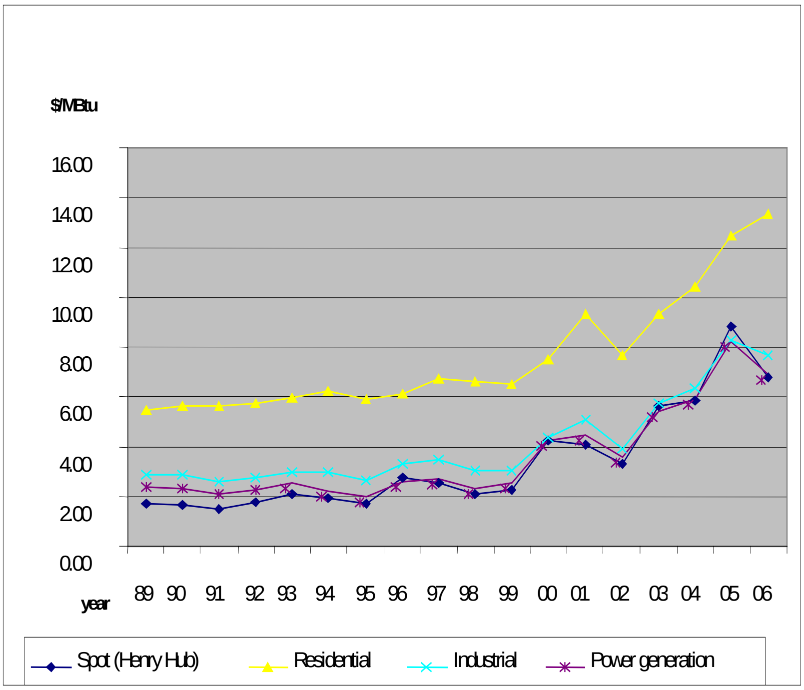


Source: BP, Energy P&T

Besides, self-contracting practises with destination flexibility have been introduced along the LNG chain, which reinforced competition in LNG pricing *(ETC, 2007)*. Thus, figure n°2 displays that LNG import rates, which were much higher than pipeline import rates during the 90's, tends afterwards to equalize to this latter. This relatively lower price of LNG can moreover be explained by technological improvements all along the LNG supply chain (liquefaction, shipping) and by progressive diversification of supplying countries. Finally, thanks to the new gas market environment in the US, characterized by declining internal reserves and rising quotes, LNG import prices are becoming more and more interesting with a view to matching American gas needs in the future.

5) End-use prices

Figure n°3: End-use average prices of natural gas in US (1989-2006)



Source: US DOE

Rates applied to the industrial and power sector tend to harmonize over time by moving closer to the spot price. Walls (1994, cited by Park, Mjelde & Bessler 2007) has indeed discovered that the city gate prices at certain locations are co-integrated with field market prices (wellhead). Household tariffs are higher than other quotes by a factor 2. This residential over-tariff (which is a world-wide feature) is caused by additional costs that are specific to that sector: distribution costs, which structurally represent a major part of the final price. Those distribution charges usually correspond to the commercial margins levied by LDCs at the city gate before delivering to small consumers.

However, end-use sectors (residential, industrial and electrical) have natural gas delivered under different technical conditions; they have different demand functions, including a variety of factors. But in spite of that variability, convergences between existing ranges of price, combined with a relatively low level of gas tariffs, attest the success of deregulation policies in the United States.

6) US gas prices

Table of US gas prices ($/Mbtu)

	WHOLESALE				END-USE		
year	**Spot** (Hen.H.)	**Well head**	**Pipe import***	**LNG import***	**House holds**	**Industry**	**Power G**
1989	1.70	1.64	1.76	2.15	5.47	2.87	2.36
1990	1.64	1.66	1.85	2.40	5.63	2.84	2.31
1991	1.49	1.59	1.76	2.29	5.65	2.61	2.11
1992	1.77	1.69	1.78	2.46	5.71	2.75	2.29
1993	2.12	1.98	1.96	2.13	5.98	2.98	2.53
1994	1.92	1.79	1.80	2.21	6.22	2.96	2.21
1995	1.69	1.50	1.44	2.23	5.88	2.63	1.96
1996	2.75	2.10	1.90	2.72	6.15	3.32	2.61
1997	2.52	2.25	2.09	2.66	6.73	3.48	2.70
1998	2.08	1.90	1.89	2.55	6.62	3.05	2.33
1999	2.27	2.12	2.16	2.40	6.49	3.01	2.54
2000	4.23	3.57	3.86	3.40	7.53	4.35	4.25
2001	4.06	3.88	4.31	4.22	9.34	5.08	4.47
2002	3.34	2.86	3.04	3.31	7.65	3.90	3.57
2003	5.62	4.73	5.07	4.65	9.34	5.71	5.40
2004	5.85	5.30	5.63	5.65	10.43	6.33	5.93
2005	8.80	7.11	7.85	8.01	12.45	8.30	8.23
2006	6.76	6.23	6.63	6.97	13.34	7.65	6.88

* average price

Source: DOE, BP, Energy P&T

Europe

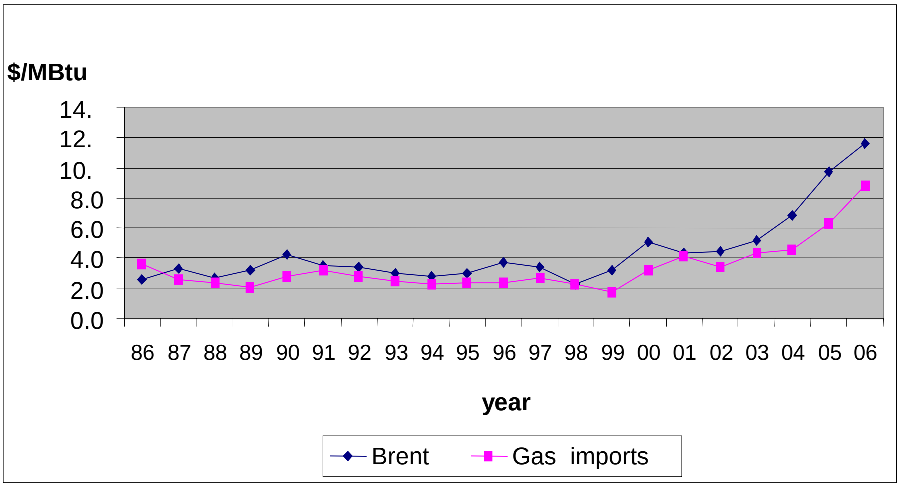
1) The pricing structure in Continental Europe

Continental Europe relies increasingly on gas imports. Transactions generally regard large volumes extracted from giant fields. Natural gas is imported through long-term contracts from Russia, Algeria, Norway, Nigeria or Libya (but gas can be bought inside the European Union: the United Kingdom, Germany, the Netherlands, Italy…).

In Continental Europe, the pricing is based on the "replacement value" of gas, which corresponds to the value of alternative energies on the final gas markets inside the buyer's country. This market value of gas is then netted back to the exporting state's border by subtracting intermediary charges to deliver to the customer (transportation cost, distribution cost and other costs), and this gives the final reselling price (the producer price). Historically, this concept of long-term contract with a price based on replacement value was designed first for exports from the Dutch field of Groningen (first large reserve discovery in Europe).

Moreover, contracts include a review clause: price is adapted regularly in line with the development of the competitive situation of gas in each of the residential, industrial and power sectors. In other words, the price formula is re-calculated (usually every three months) in order to reflect movements in the share of gas in power generation, and changes in the mix of the competing fuels, mainly light fuel oil and heavy fuel oil but also crude oil, coal, electricity or inflation *(ETC, 2007)*. More recently, since the creation of the Interconnector between the UK and the Continent, a reference to gas-to-gas competition has been integrated in the indices. But despite variations in the shares of different components, the price of gas in Continental Europe remains mainly pegged to fuel oil products. The Energy Sector Inquiry (ESI, 2007) empirically confirms that the rates of European long-term contracts are mainly linked to oil and oil derivatives, according to a volume-weighted indexation.

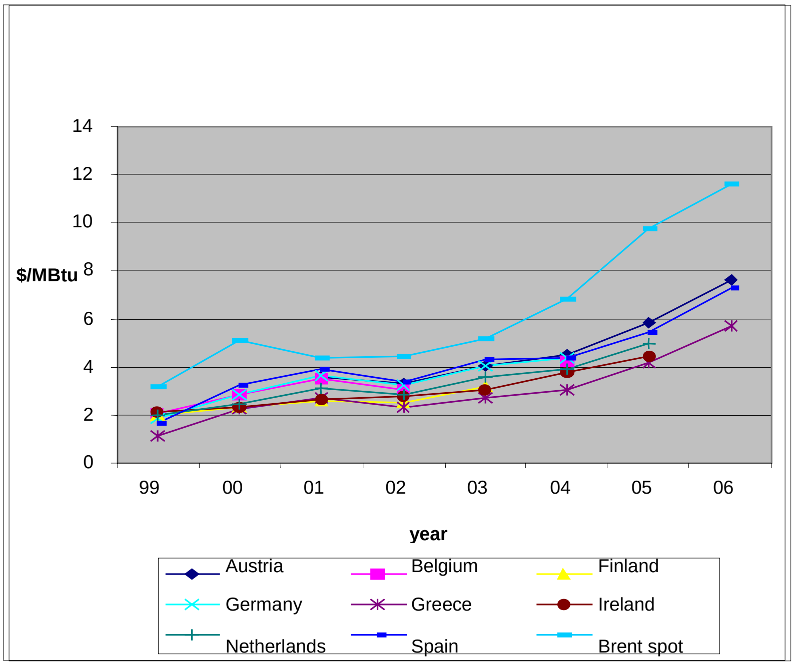
Figure n°4: Average import price of natural gas in EU (1986-2006)



Source: BP, Energy P&T

Indeed, in figure n°4, due to a wide indexation to fuel oil products, the import contracts average price in Continental Europe closely tracks the oil barrel, although with a lag of more or less 6 months. According to Siliverstives, I'Hegaret, Neumann & von Hirschausen (2004), import gas prices in Europe follow developments in North Sea Brent Crude Oil (a reference for many gas import contracts in Europe) with a lag of about 4-8 months. As shown in figure n°5, purchase prices all over Europe consequently move in an identical manner.

Figure n°5 Average import prices in EU member states (1999-2006)



Source: Energy P&T

To be more precise, the indexation pattern varies by import source. According to the ESI, imports from Russia, Norway and the Netherlands have a similar indexation with a pegging of over 80% to fuel oil products and as a result, gas purchased from those countries display similar price levels. By contrast, Algerian gas is mostly linked to crude oil for 70% (it is the cheapest gas sold in Europe).

Price indexation also varies according to the purchaser's region, with a big split between the UK and Continental Europe. In the UK, fuel oil products account for only 30% of the total pegging. On Continental Europe, the importance of fuel oil is much higher: 80% in Western Europe, 95% in Eastern Europe.

The observation of price convergence between different member states provides a good indicator of the achievement of the European internal gas market since liberalizing reforms were undertaken (European Single Act of 1986, EU Gas Directives of 1998 & 2003). For instance, using co-integration analysis of import prices, Asche, Osmunden & Tveteras (2001, 2002, cited by Robinson, 2006) infer that the French, Belgium and German markets are integrated.

2) Spot developments

It seems obvious that the continental import model is not favorable to a reactive gas price based on gas-to-gas competition. There is in fact a weak price-elasticity of demand on the Continent, which comes from two factors: gas imports often involve wholesale players (national companies) on both sides of the exchange, and natural gas is used less in power plants in Continental Europe than in the UK or the US *(ETC, 2007)*. Despite substantial measures aimed at creating a single competitive gas market (removal of destination clauses and take-or-pay obligations, mandatory Third Party Access), long-term contracts still remain the dominant practice for imports of natural gas, although with a fostered flexibility.

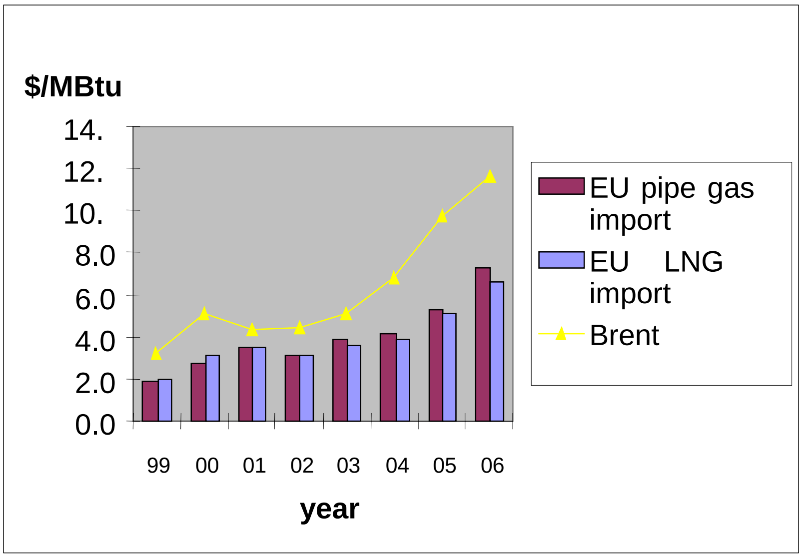
Owing to the new regulatory environment, several gas hubs have nevertheless developed through Western Europe: Zeebrugge in Belgium, Bunde in Germany, Title Transfer Facility (TTF) in the Netherlands (virtual)… The pricing at those spots reflects the supply and demand situation. But, because they still welcome mainly large industrial players, such trading hubs have reduced activity. Therefore, they have a low liquidity, which allows for price manipulations *(ESI, 2007)*. Neumann, Siliverstovs & von Hirschausen (2005, cited by Robinson 2006) find for example that prices at Zeebrugge and Bunde are not connected. Moreover, hub prices are much more volatile than long-term contract rates. They display a seasonality trend, due to climate conditions (a fall in demand during summer, a rise during the winter) *(ESI, 2007)*

3) LNG pricing

In Continental Europe, LNG imports rely on traditional long-term contracts mainly from Algeria, and also from Nigeria or Trinidad. Price is pegged to crude oil or oil products, but due to increasing competition from pipeline gas, the indexation pattern for LNG tends to follows the same structure as on-shore gas, with references to coal, electricity… More generally, the liberalization process on the Continent is making LNG pricing more competitive *(ETC, 2007)*.

Figure n°6 clearly supports these facts. The pegging to crude oil is obvious. Consequently, pipe import and LNG import display similar price levels year after year. Siliverstives, l'Hegaret, Neumann & von Hirschausen (2004) assert that this co-movement of LNG and piped gas, caused by similar contract and price structure, provides evidence of regional gas price integration in Continental Europe. Moreover, price competitiveness of LNG relative to piped gas is constantly improving: while in 1999, LNG deliveries were more expensive than piped gas, LNG became cheaper in 2002; and by 2006, the LNG price was 6.62 $ / MBtu, piped gas costs 7.32 $ / MBtu.

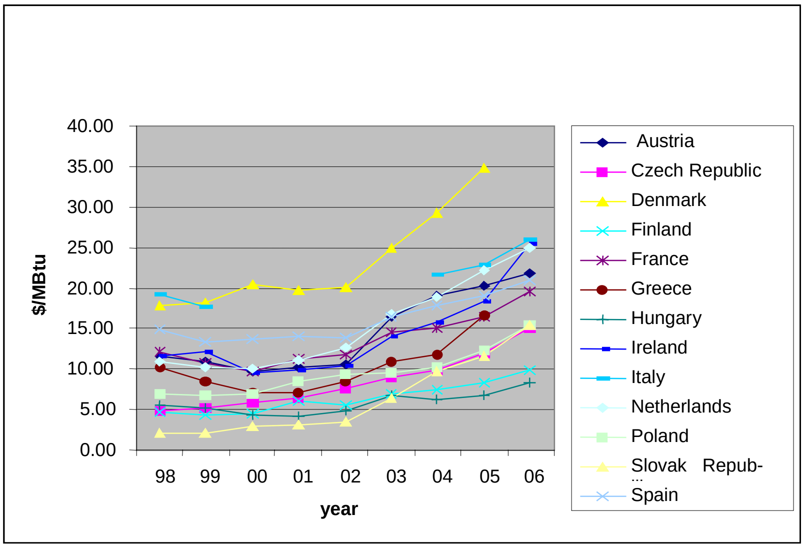
Figure n°6: Gas imports average price in EU (1999-2006)



Source: Energy P&T

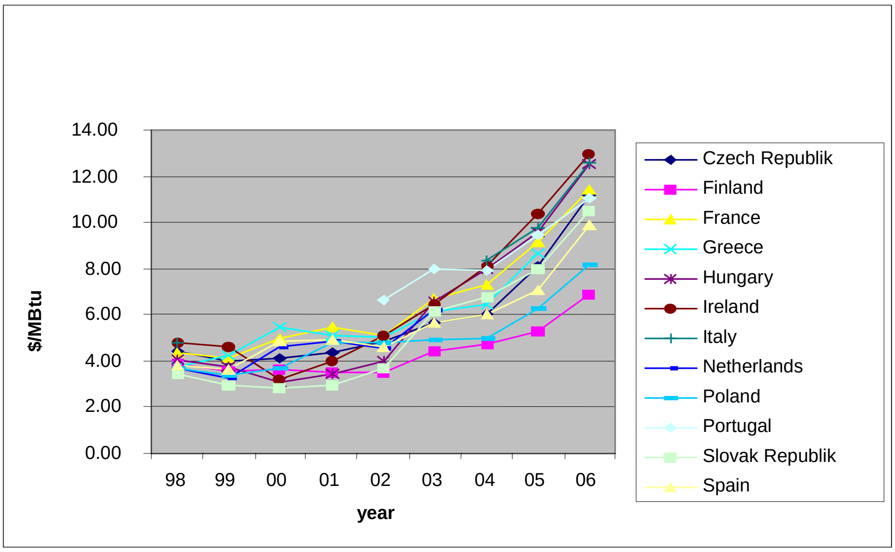
4) Retail prices

Figure n°7: Residential gas prices in EU member states (1998-2006)



Source: Energy P&T

Figure n°8: Industrial gas prices in EU member states (1998-2006)



Source: Energy P&T

Two main features emerge: since 1998, end-use prices have strongly risen on average, and the price spread between member states has even widened. On those two points, gas directives seem to have more or less failed in the short term since the opening policy was theoretically supposed to generate both lower prices and price convergence. However, conjuncture factors, like the recent surge in international oil markets, account for the boost in retail gas prices (final gas prices in the residential, industrial and power sector are indeed based on the market value of substitutes, mainly fuel oil).

Moreover, the persistent price divergence across Europe has a structural explanation, such as substantial differences in national taxation (especially in the residential sector, where the percentage of taxes ranges between 5% in the UK and 33% in Netherlands as of 2006). Recently, an important bias was introduced by the termination of cross-subsidies between end-use sectors (large users would indirectly finance small users). Put more simply, the gaps can be linked to differences in transportation and distribution costs that are included in the final price (for example, Eastern countries, closer from Russia, bear lower transportation charges). Asche, Osmunden & Tveteras (2002) justify the relative price discrepancy through Europe by pointing to the natural complexity of gas import contracts, which depend on a wide range of elements, including political risk and even oil taxation.

However, Robinson (2007) analyses retail gas prices trajectories in the long term inside the European Union. Based on a sample of member states, he notices a long-run convergence of national prices between 1978 and 2004, reflected by diminishing price differentials over time.

5) The case of the United Kingdom

a) main features

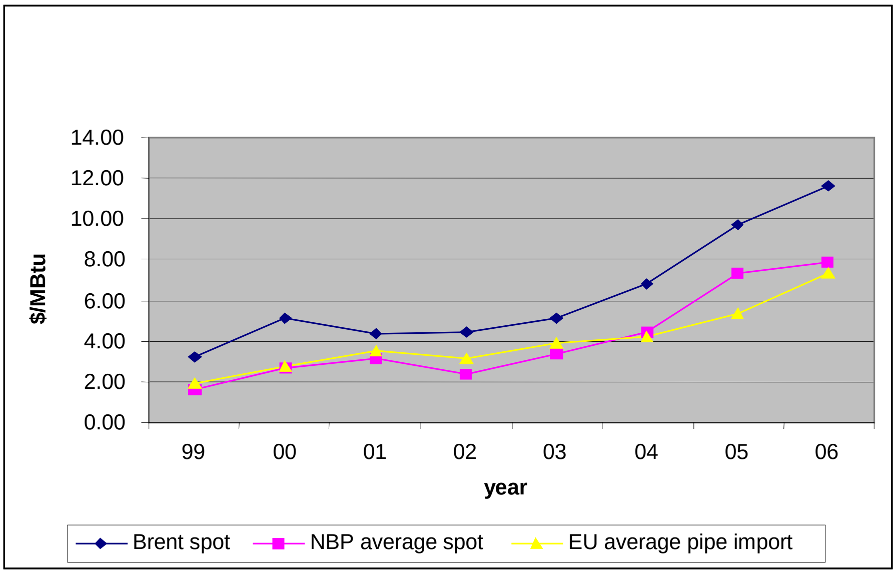
Contrary to the Continent, which is still dependent on long-term contracts, the British gas industry is fully liberalized. In this sense, it follows closely the current North American paradigm, thus displaying similar features: spot transactions, responsive short-term pricing and gas-to-gas competition. But while Henry Hub represents a physical spot, the National Balancing Point is a virtual point, an intangible trading place which quotes prices for all gas passing through the national grid according to a system of “entry-exit” rights *(ETC, 2007)*. Linked to the NBP, a futures market for gas has developed at the International Petroleum Exchange.

b) price history and formation

The Natural Gas Act of 1986 triggered a large movement of deregulation, by introducing Third Party Access and also by terminating British Gas’s monopoly selling and monopsony buying of gas. In the meantime, the electric power industry was liberalized in 1989. This relieved power plants from the obligation to use coal, thus setting a more price-elastic demand for gas. In 1998, the supply of the residential sector was opened to free competition, which drove down NBP rates *(ETC, 2007)*.

Since then, trends of gas rates are more or less coupled with the trajectory of alternate fuels (gas oil, heavy fuel oil). Thus, despite the existence of a well-developed spot market for gas in the UK, which theoretically involves an autonomous gas price formation based on national fundamentals, figure n°9 establishes a correlation between NBP prices and crude oil references over the recent period.

Figure n°9: Comparison between NBP spot, EU import and oil barrel (1999-2006)



Source: BP, Energy P&T

Due to a recent decline in North Sea production, the United Kingdom switched in 2004 from being a net exporter to a net importer, and this led to a strengthening in British gas prices. Indeed, as shown in figure n°9, the NBP rate suddenly soared from an average of 4.46 $ / MBtu in 2004 to 7.38 $ in 2005. This price spike can also be explained by a more temporary factor, namely the cold winter of 2005/06.

Since 1998, the British gas sector is connected with the Continent through the Interconnector, a pipeline linking the Bacton Terminal with the Zeebrugge Hub in Belgium. The long-term export contracts to the Continent include a clause that allows the supplier arbitrage with spot prices in the UK. The price implications of the Interconnector, which enables two-way gas flows, are displayed in figure n°9. NBP spot rates and Continental contract prices show common up and down trends over the period. Indeed, gas trade and arbitrage through the Interconnector had the effect of setting a price channel between British and Continental gas (the UK market had previously remained isolated).

More precisely, before 2004, NBP prices were lower than Continental prices. These latter held as a ceiling to the UK market, which was then still wide. Nevertheless, in October 2003, with tensions emerging on British supply, Continental rates become a lower limit to NBP quotes. However, due to the Interconnector, a price equilibrium was set between the UK and the Continent *(Maisonnier, 2005)*

As recognized by the International Energy Agency (2002, cited by Ferreira, Soares & Araujo, 2003), liberalization policies in the UK have brought substantial benefits to consumers. Retail prices are lower than the EU average, especially in the household sector.

6) Table of European gas prices

Wholesale prices (average import prices, except NBP = spot price) ($/Mbtu)

Year	NBP	EU pipe	AUT	BEL	FIN	DEU	IRL	NLD	ESP	EU LNG
1999	1.58	1.88	-	2.06	2.02	1.86	2.14	1.99	1.63	2.00
2000	2.71	2.79	-	2.83	2.35	2.83	2.3	2.43	3.24	3.09
2001	3.17	3.51	3.55	3.52	2.58	3.64	2.67	3.13	3.93	3.54
2002	2.37	3.16	3.34	3.03	2.55	3.27	2.77	2.84	3.36	3.14
2003	3.33	3.91	4.06	-	3.21	4.03	3.08	3.57	4.28	3.63
2004	4.46	4.2	4.48	4.27	-	4.4	3.81	3.9	4.37	3.89
2005	7.38	5.33	5.87	-	-	-	4.42	4.95	5.45	5.1
2006	7.87	7.32	7.66	-	-	-	-	-	7.33	6.62

Source: BP, Energy P&T

End-use prices (H = Households, I = Industry, P = Power Generation) ($/Mbtu)

	Finland			France			Germany		
Year	**H**	**I**	**P**	**H**	**I**	**P**	**H**	**I**	**P**
1998	4.69	3.85	3.33	12.14	4.38	-	11.25	4.94	4.09
1999	4.34	3.56	2.99	10.77	4.09	-	10.61	4.49	3.87
2000	4.43	3.63	3.15	9.65	4.95	-	10.37	5.22	4.26
2001	6.14	3.50	3.03	11.19	5.48	-	-	-	-
2002	5.60	3.53	3.03	11.82	5.07	-	-	-	-
2003	6.94	4.41	3.78	14.49	6.72	-	-	-	-
2004	7.49	4.73	4.04	15.12	7.28	-	-	-	-
2005	8.28	5.28	4.60	16.40	9.17	-	-	-	-
2006	9.79	6.89	6.20	19.64	11.45	-	-	-	-

Source: BP, Energy P&T

	Italy			Netherlands		
Year	**H**	**I**	**P**	**H**	**I**	**P**
1998	19.19	4.76	-	10.93	3.69	3.38
1999	17.73	-	-	10.25	3.24	-
2000	-	-	-	9.98	4.63	-
2001	-	-	-	11.15	4.88	-
2002	-	-	-	12.70	4.57	-
2003	-	-	-	16.74	6.18	-
2004	21.62	8.35	-	18.96	-	-
2005	22.87	9.77	-	22.23	-	-
2006	26.02	12.62	-	24.99	-	-

Source: BP, Energy P&T

	Spain			United Kingdom		
Year	**H**	**I**	**P**	**H**	**I**	**P**
1998	14.81	3.83	3.56	9.18	3.02	3.51
1999	13.35	3.65	3.33	8.92	2.86	3.19
2000	13.65	4.87	4.58	8.13	2.91	2.89
2001	14.11	4.89	-	7.96	3.90	3.09
2002	13.80	4.60	-	8.81	4.07	2.95
2003	16.51	5.67	-	9.77	4.58	3.60
2004	17.87	5.99	-	11.75	5.63	4.50
2005	19.02	7.06	-	13.38	8.30	5.96
2006	21.03	9.86	-	17.88	10.66	7.64

Source: BP, Energy P&T

Asia

1) Gas sector overview

The current Asian market for gas is composed of Japan, Korea, Taiwan, and for a few years, China and India. These countries import from Malaysia, Indonesia, Australia, the Middle East and the United States. The construction of an international pipeline grid being too costly due to the specific geographical aspect of the Asian Continent, importing economies are almost totally dependent on Liquefied Natural Gas, supplied through medium and long-term contracts. In Japan, there is a substantial coupling between gas and electricity sectors, LNG purchases being mainly routed to electricity generators. Because of this linkage, gas markets in Northeast Asia are vertically integrated, although in Japan and Korea, a few juridical steps have been made recently towards the opening of the retail supply *(Skeer, 2004)*.

2) LNG price determination and evolution in Asia

Liquefied Natural Gas import prices in the Pacific Basin are more expensive by roughly 1 $ / MBtu compared with the Atlantic Basin. This premium (the "Asian premium") is due to long-haul shipping of gas, high charges applied to the use of LNG terminals and lastly the absence of competition from piped gas.

Since the 90's, the Northeast Asian pricing formula is based on the Japanese pattern, and is P=a+bX type. It is split between two components: a base part (a), constant, set firmly by negotiation, and a floating part, termed "escalator" (X), designed to reflect variations in oil rates. Usually, a coefficient ("pass-through factor", b**,** inferior to unit) is used to integrate petroleum tendencies in the Liquefied Natural Gas price.

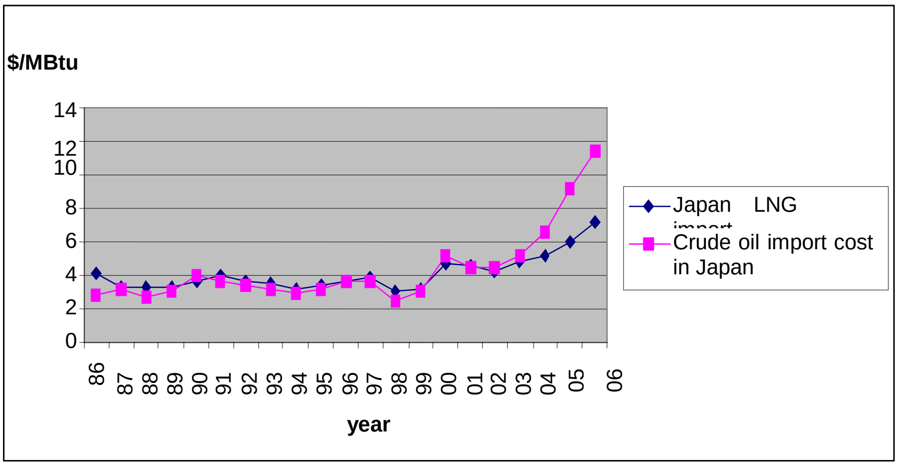
A very common price escalator in the Asia Pacific region is the Japanese Crude Cocktail (JCC), a basket of different crude oils imported from the Middle East. Such a benchmark is another factor of the Asian gas price premium: shipping crude oils from the Middle

East to Japan is particularly expensive while, for example, European gas prices are only linked to pre-burner competitive prices – mainly oil products *(Fujime, 2005)*.

Moreover, floor and capping mechanisms were introduced in the pricing system in order to regulate the impact of barrel ups-and-downs. This curving factor, which acts as a "shock absorber", thus mitigates the direct effect of higher or lower oil prices for the sake of the buyer or seller *(Suzuki)*. Nevertheless, with the emergence of tight competition for LNG in Asia, those price limits have been softened or eliminated *(ETC, 2007)*.

For three decades, LNG pricing in Asia has been punctually re-adjusted in line with the ups-and-downs in the oil market, in order to maintain a financial compromise between importers and suppliers. More precisely, the base price (a) and the pass-through factor (b) were re-calculated (a being lowered and b raised, or conversely). Over the recent period, with the barrel skyrocketing, the base price for LNG has been set at a higher level in line with the new fundamentals of the oil market, but the linkage coefficient to oil has been flattened in order to reduce the potential effects of the barrel surge. Moreover, the price-capping mechanism, by maintaining LNG quotes under a certain threshold, has more or less led to a de facto decoupling from petroleum conditions *(ETC, 2007)*.

Figure n°10: LNG average import price in Japan (1986-2006)



Source: Energy P&T

The linkage to crude oil appears in figure n°10, and is explained by the JCC reference in the LNG pricing formula. However, since 2002 and the oil price flare-up, purchase rates of LNG have risen, but to a much lesser extent. This is due to moderating instruments in the LNG price: price-capping, pass-through factor.

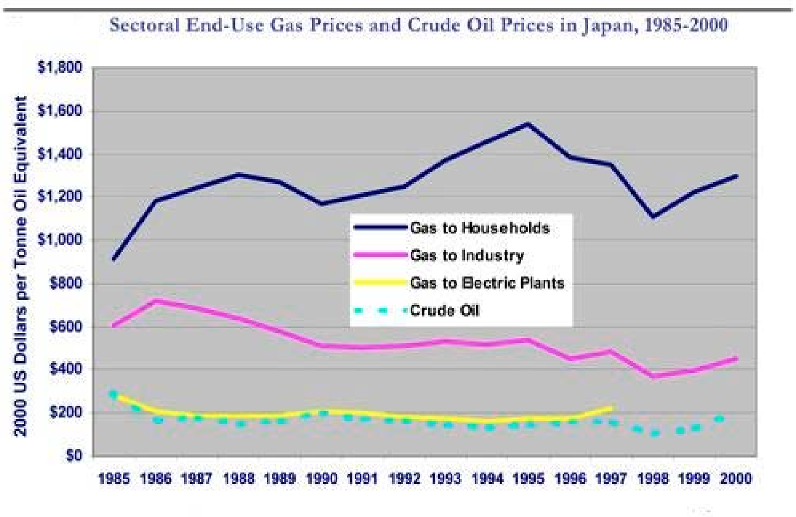
Geographically, China and India represent a convergence point in Asian LNG pricing. Indeed, these countries started to import LNG at a time when Asian demand for natural gas was still low (beginning of 2000's). Moreover, the important size of these two potential markets triggered an active competition between LNG suppliers to penetrate them. In this context, Chinese and Indian prices for LNG were negotiated at particularly low levels with a weaker pegging to oil rates. Such prices still more or less prevail despite the strengthening of hydrocarbon markets. Consequently, when renewing their contracts, Northeast Asian LNG purchasers target lower rates in accordance with Chinese prices. Importers also invoke reduced LNG technical costs to obtain price cuts.

However, gas price determination in Asia should become more and more competitive due to the diversification of LNG import sources, densification of gas infrastructures (new terminals and pipelines projects), multiplication of players at different levels of the supply chain (from the exporting country to the end-user), and increased pressure from competing fuels in electricity generation (clean coal and nuclear).

3) End-use prices

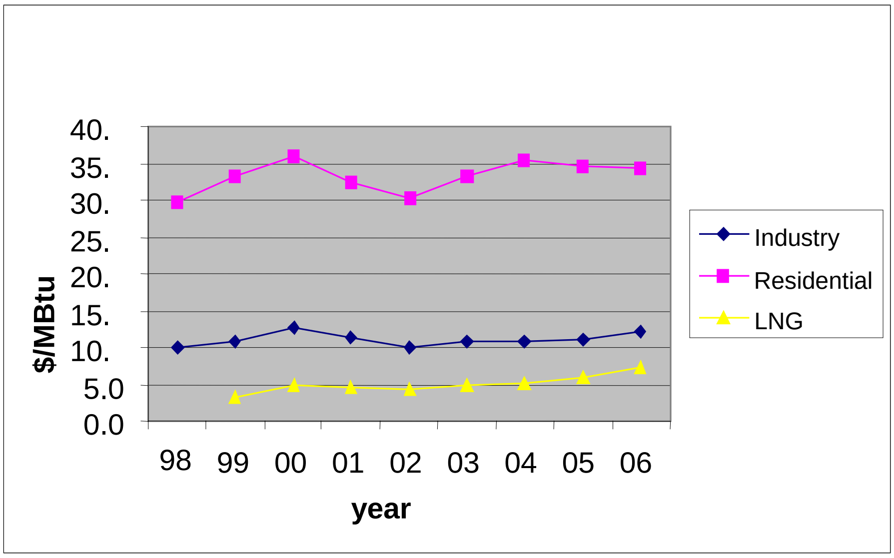
Contrary to the case of United States or Europe where wholesale and retail trends are coupled, there is an important dichotomy between import and end-use rates in Japan. In figures n°11 & 12, one notices the particularly high level of quotes applied to households, which are by far the most expensive of the three global regions. For example, during 2006, households would pay 13.34 $ / Mbtu on average in the US, while they would be charged more than 34 $ in Japan.

Figure n°11: Sectoral end-use gas prices and crude oil prices in Japan (1985-2000)



Source: International Energy Agency, provided by Skeer, 2004

Figure n°12: End-use gas prices in Japan

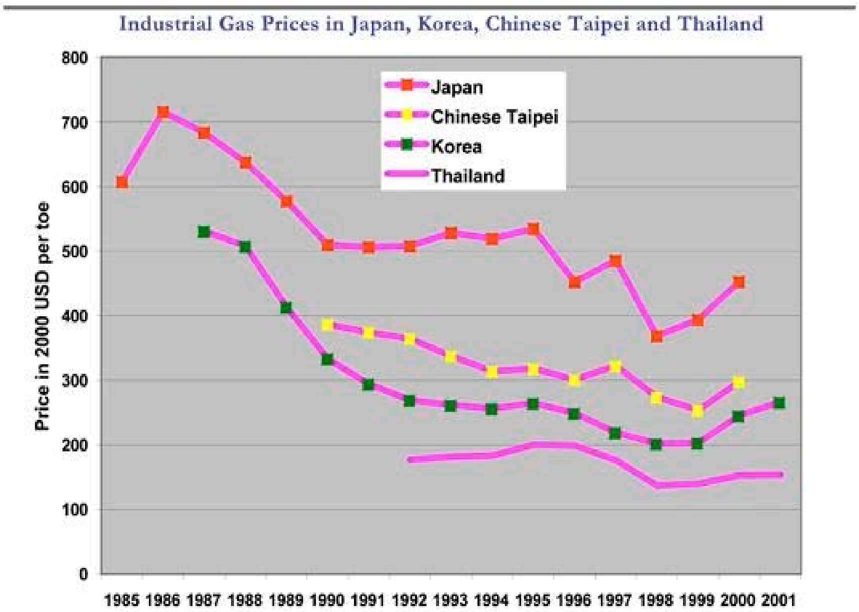


Source: Energy P&T

In fact, retail price structure in Japan can be explained by the industrial organization, in other words by a differentiated access point to gas. Residential or commercial customers, who can be supplied only through the final distribution grid, pay both transmission and distribution charges. Industrial users, who can connect directly to high-pressure pipelines, pay only transmission charges (which are rather high charges). Electric utilities usually receive gas deliveries at their own LNG terminals, and therefore bear lower costs. As a consequence, retail prices for electricity are closely linked to the trend of crude oil (figure n°11), while industrial and residential rates, including substantial transmission and distribution charges, are more loosely linked to the barrel. Finally, in Japan, gas prices for electricity are twice lower than gas for industry, which is itself twice or three times cheaper than residential tariffs *(Skeer, 2004)*.

However, as shown in figure n°13, there is an important variability in end-use prices throughout Asia. In the case of households, distribution charges can vary substantially from one country to another, leading to ranges in residential rates *(Skeer, 2004)*.

Figure n°13: Industrial gas prices in Japan, Korea, Chinese Taipei and Thailand



Source: International Energy Agency, provided by Skeer, 2004

4) Northeast Asian gas prices

Table of Northeast Asian Gas Prices ($ / Mbtu)

	Japan				Korea			
Year	**LNG***	**House holds**	**Industry**	**Power G**	**LNG***	**House holds**	**Industry**	**Power G**
1998		29.68	9.89	-	-	-	-	-
1999	3.18	33.24	10.72	-	3.15	-	-	-
2000	4.73	35.95	12.58	-	2.04	-	-	-
2001	4.64	32.45	11.29	-	4.95	-	-	-
2002	4.32	30.18	9.92	-	4.41	-	-	-
2003	4.82	33.20	10.69	-	5.03	-	-	-
2004	5.23	35.32	10.90	-	5.74	12.62	9.50	8.14
2005	6.04	34.60	11.15	-	6.96	14.67	10.90	10.20
2006	7.18	34.40	12.09	-	8.75	17.82	13.76	13.25

*average import price
Source: Energy P&T

Conclusions

First of all, we noted the fundamental importance of regulation in gas pricing. Price efficiency, levels, transparency and the related social welfare varies substantially between the USA, the UK, Continental Europe and Northeast Asia since those regions are simply situated at different stages of the liberalization movement. In other words, they are at different points in the temporal evolution towards a freed gas market, along an East-West axis:

- Northeast Asia is in the first stages of the liberalization process, although measures or trends have been recently taken in this direction. A more deregulated sector could emerge during the 2010's.

- Continental Europe, where the gas market has been legally opened since the 2000's, is still in the long-term transition between an old, rigid, regulated, monopolistic model and the targeted competitive situation.

- Then, the United Kingdom, whose gas market has been open since the 90's, is obviously more advanced in the deregulation procedure, but structural improvements still need to be done, such as increasing the liquidity at the National Balancing Point.

- Finally, North America, liberalized since the 80's, is by far the most competitive area: gas market opening is now complete, and the market for gas is nearly a "total market". The American gas sector represents a paradigmatic target for European and Asian markets.

In the United States, the liberalization movement proved pragmatically a success: US gas tariffs are converging, and are currently lower than in the rest of the world. Gas pricing is essentially intra-sectoral, but alternate energies like oil and coal still play a price regulator, according to the economic rule of substitutable goods on the consumer's side. Despite the existence of a regulatory framework favorable to gas-to-gas competition and moderate prices, the recent emergence of physical constraints (declining domestic resources, rising import needs) should raise US gas prices in the future.

In Europe, the case seems more complicated. It is maybe too early to assess the final effect of the directives on gas prices. The recent upwards bias induced by the third oil shock furthermore complicates the legibility of gas price trajectories. At its core, there is a technical, economic, juridical and fiscal disparity of gas sectors throughout the Continent. Despite decisive steps made towards a single gas market, this complexity of the European gas world might delay retail price harmonization in the short-term.

There is a common agreement that indexation of European prices on oil products should still prevail in the near future, because traditional long-term contracting represents for players an essential way to secure gas transactions (reservation of transportation capacities…). But owing to higher flexibility requirements and the growing use of gas in electricity production, the oil reference should be less determining. More relevant indicators, like gas spot prices at various hubs or power quotes could play an increased role. Moreover, contract prices should coexist with spot prices in the landscape of the coming decades, considering the forecasted importance of spot hubs in European gas.

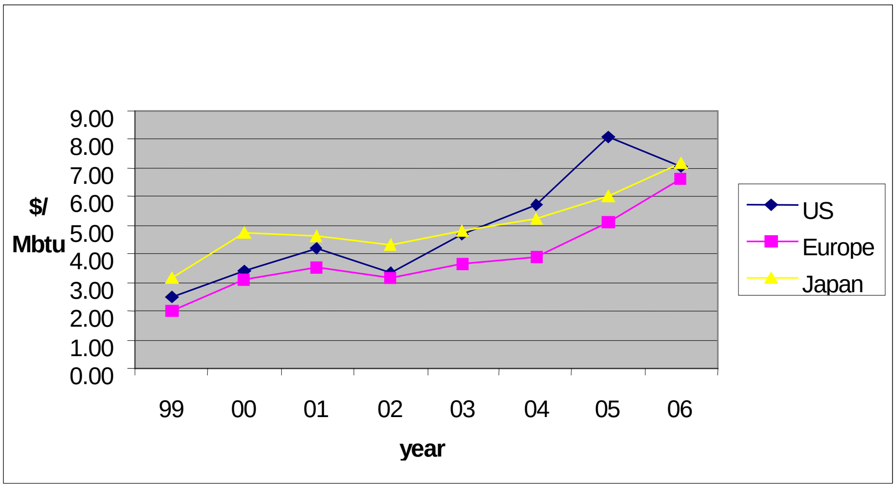
Concerning price levels in Europe, high rates could be persistent due to a strengthened structural dependence on external imports. However, competitive pressures generated by deregulation, entry of multiple players at different stages of the value chain and geographical diversification of import sources should maintain gas prices in bearable limits.

Regarding Asia, gas price levels are rather expensive due to a long geographical distance between producing regions and consuming locations, which indeed involves high transportation costs. The Asian pricing system is particularly rigid, so a lot of additional welfare can be expected from liberalization policies. In any case, multilateral competitive pressures following the rising importance of Asia in international gas should naturally generate improved market efficiency. Substantial price cuts can also be obtained through technological progress in the production and transportation of LNG. Nevertheless, despite an active diversification of supplying sources, the boosting Asian LNG demand, fueled by China or India, might generate a spike in LNG prices inside this region

We turn now to the second question asked in the introduction of this paper: is a global price for natural gas emerging? This issue is directly related to the case of LNG, since LNG shipped through maritime tankers allows for intercontinental gas trade (LNG becomes very competitive compared with piped gas over long distances). Continuously declining LNG costs should furthermore reinforce international LNG trade and arbitrage.

Currently, there is important LNG arbitrage between the United States and Europe. With Africa and the Middle East becoming significant suppliers of LNG, an arbitrage activity is also developing between the Atlantic Basin and the Asia Pacific Basin. Siliverstives, l'Hegaret, Neumann & von Hirschausen (2004) thus mentions co-movements between LNG import prices in Europe and in Japan by 2004. Nevertheless, North American price moves slightly differently than in other regions. Figure n°14 confirms the integration of LNG quotes between Europe and Japan, and the existing split with North American prices. However, by 2006, one observes a price convergence and equalization between the three LNG regions: LNG average import cost is 6.62 $ / MBtu in Europe, 7.05 $ in the US and 7.18 $ in Japan.

Figure n°14 LNG average import price (1999 2006)



Source: Energy P&T

In Europe and the US, LNG represents a small portion of the natural gas supply. This tends to restrict LNG arbitrage in its ability to transmit price signals and initiate a gas price harmonization between regional markets. Moreover, international spot arbitrage might be limited by the persistence of long-term contracting as a mean to secure LNG capital investments.

Finally, there is a widespread feeling that, rather than a single world gas price, we might observe correlations or convergences between regional prices within the next several years. Of course, this doesn't preclude the thesis of a unique gas price in the long-term.

The dollar, invoicing currency in international trade, has been the unit mainly used in gas imports to the United States, Europe and Asia. In the recent context of the dollar depreciation, the United States suffers relatively more from the recent surge in purchase prices than Europe and Asia, where the rise can be partly eliminated through currency translation (such a situation prevails more generally in the hydrocarbons market). Thus, the United States could partly loose their natural price advantage over other gas regions for monetary reasons (unfavorable exchange rate), combined with sectoral ones (higher dependence on external imports) and also due to globalization (more price channels between regions).

Concerning the European Union, gas import contracts should be increasingly expressed in euros, as the dollar becomes less relevant. In the meantime, exporting countries (especially inside the Middle East) tend to diversify their selling currencies beyond the dollar. Indeed, they opt for stronger currencies, intending to cushion their revenue shortfall caused by the dollar depreciation.

Bibliography

ARAUJO, M., P. FERREIRA & I. SOARES, “Liberalisation, consumption heterogeneity and the dynamics of energy prices”, *Energy Policy*, vol. 33, n° 17, November 2005, pp. 2244-2255

ASCHE, F., P. OSMUNDEN & R. TVETERAS, “European market integration for gas? Volume flexibility and political risk”, *Energy Economics*, vol. 24, n° 3, May 2002, pp. 249-265

AUSTVIK, O. G., “Gas pricing in a liberalized European market; will the rent be taxed away?”, *Energy Policy*, vol. 25, n° 12, 1997, pp. 997-1012

BALL, A., “Asia Pacific LNG Market”, *Australian Commidities*, vol.12, n°2, June 2005, <abareonlineshop.com/PdfFiles/PC13158.pdf>

BESSLER, D., H. PARK, & J. MJELDE, “Price interactions and discovery among natural gas spot markets in North America”, *Energy Policy*, vol. 36, n° 1, January. 2008, pp. 290-302

CHEVALIER, J.-M., “Détermination du Prix du Gaz Naturel”, *in* Maurice J. (dir.), *Rapport « Prix du pétrole »*, Complément G, pp. 147-150, Paris, Conseil d’analyse économique/La Documentation Française, 2001

DALE, L., G. WONG-PARODI & A. LEKOV, “Comparing price forecast accuracy of natural gas models and futures markets”, *Energy Policy*, vol. 34, n° 18, December 2006, pp. 4115-4122

ENG, G., “A Formula for LNG pricing”, Ministry of Economic Development, New-Zealand, May 2006, <abareonlineshop.com/PdfFiles/PC13158.pdf>

FELDER, F. A., “Modelling natural gas prices as a random walk: The advantages for generation planning”, *The Electricity Journal*, vol. 8, n° 9, November 1995, pp. 61-67

FESHARAKI, F., K. WU & S. BANASZAK, *Natural Gas: The Fuel of the Future in Asia*, Hawai, East West Center, 2000, <www.eastwestcenter.org/fileadmin/stored/pdfs/api044.pdf>

FISHHAUT, E., “LNG makes headway”, *Global View*, 2005, <www.globalviewsoftware.com/download/editorials/Mrktfocs-Jun-05.pdf>

FUJIME, K., LNG Market and Price Formation in East Asia, Tokyo, Institute of Energy Economics, Japan, 2002, <eneken.ieej.or.jp/en/data/pdf/127.pdf>

GALLON, S., "Les Perspectives du Marché du Gaz en Europe", *in* Maurice J. (dir.), *Rapport « Prix du pétrole »*, Complément H, pp. 151-170, Paris, Conseil d'analyse économique/La Documentation Française, 2001

JOHNSSON, F. & J. KJARSTAD, "Prospects of the European gas market", *Energy Policy*, vol. 35, n° 2, February 2007, pp. 869-888

L'HEGARET, G., A. NEUMANN, B. SILIVERSTOVS & C. VON HIRSCHHAUSEN, "International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan", *Energy Economics,* vol. 27, n° 4, July 2005, pp. 603-615

LIEN, D. & T. ROOT, "Convergence to the long-run equilibrium: the case of natural gas markets", *Energy Economics* vol. 21, n° 2, November 1999, pp. 95-110

MACAVOY, P. & N. MOSHKIN, "The new trend in long-term price of natural gas", *Resource & Energy Economics*, vol. 22, n° 4, October 2000, pp. 315-338

MAISONNIER, G., "The ties between natural gas and oil prices," *Panorama 2006, Natural gas: what growth, for what markets, as regards high oil prices?*, Rueil-Malmaison, IFP, 2006, <www.ifp.fr/IFP/en/events/panorama/IFP-Panorama 06_11-LiensPrixGazPetrole-VA.pdf>

MORITA, K., LNG: Falling Price and Increasing Flexibility of Supply, Tokyo, Institute of Energy Economics, Japan, March 2003, <eneken.ieej.or.jp/en/data/pdf/185.pdf>

ROBINSON, T., "Have European gas prices converged?", *Energy Policy*, vol. 35, n° 4, April 2007, pp. 2347-2351

SKEER, J., *Asian LNG Trade and Gas Market Reform: Implications for Gas and Power Consumers*, Oxford, Oxford Institute for Energy Studies, NG 6, November 2004, <www.oxfordenergy.org /pdfs/NG6.pdf>

SUZUKI, T., *Future LNG price in Asian Market*, Tokyo, Institute of Energy Economics, Japan, 2006, <www.igu.org/html/wgc2006/pdf/paper/add10929.pdf>

WIDDERSHOVEN, C. "LNG ruling the world? OPEC loosing grip", <www.mideastinfo.com/library/cw-lng-rules.htm>

"Natural Gas Prices," BP Statistical Review of World Energy 2007, <www.bp.com/sectiongenericarticle.do?categoryId=9017915&contentId=7033439>

"Putting a Price on Energy: International Pricing Mechanisms for Oil and Gas," Energy Charter Secretariat, March 2007, Energy Charter Treaty, <www.encharter.org/index.php?id=218>

"DG Competition Report on Energy Sector Inquiry," European Commission, competition DG, SEC (2006) 1724, 10 January 2007, <ec.europa.eu/comm/competition/sectors/energy/inquiry/index.html>

"Energy Prices & Taxes, Quarterly Statistics, Third Quarter 2007," IEA Statistics, OCDE/International Energy Agency, <www.iea.org/w/bookshop/add.aspx?id=59>

"Analysis: Liquefied Natural Gas, Dawn a Global Market", *Petroleum Economist*, March 2007, <www.lng15.com/index.asp?urlgo=newsletter411>

"Information on Natural Gas," UNCTAD, Infocomm, <www.unctad.org/infocomm/anglais/gas/sitemap.htm>

"Natural Gas Data," US Energy Information Administration, US Department of Energy, <www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html>